UNIVERSITY OF ALBERTA

IMPACT OF HYPOLIMNETIC OXYGENATION ON PROFUNDAL MACROINVERTEBRATES IN A EUTROPHIC LAKE IN CENTRAL ALBERTA

BY

WILLIAM PAUL DINSMORE

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The undersigned certify that they have read and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled **IMPACT OF HYPOLIMNETIC OXYGENATION ON PROFUNDAL MACROINVERTEBRATES IN A EUTROPHIC LAKE IN CENTRAL ALBERTA** submitted by **WILLIAM PAUL DINSMORE** in partial fulfillment for the degree of **DOCTOR OF PHILOSOPHY**.

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Abstract

Profundal (15 to 25 m) macroinvertebrate responses to hypolimnetic oxygenation in Amisk Lake, Alberta, were dominated by Chironomus spp. Mean densities and biomasses of C. anthracinus at 25 m increased 55- and 109-fold, respectively, in the treated basin, but major changes in abundance were not apparent until 2 yr after treatment commenced. Densities of C. anthracinus increased similarly in the reference basin, but mean larval weights and biomasses were significantly lower than in the treated basin (paired t-test, $P < 0.001$). Anoxic conditions, rather than low temperatures, appeared to limit profundal C. anthracinus distribution in Amisk Lake. Densities and biomasses of C. cucini were higher in the reference basin than in the treated basin of Amisk Lake. Densities of C. decorus and C. plumosus group increased in the treated basin but remained of minor importance. In comparison, densities of C. cucini and C. plumosus group in Baptiste Lake, a reference site, declined over the study period. Densities of other macroinvertebrate taxa remained low in the profundal region of Amisk Lake. Shannon-Weaver indices of diversity decreased as oxygenation progressed, in contrast to aeration studies in other locations. Increased Chironomus spp. abundance in Amisk Lake suggested an increase in fish food, but fish foraging below 15 m was restricted by low DO concentrations and water temperatures.

The relationship between profundal macroinvertebrate biomass (PMB) and DO concentrations has never been empirically investigated. PMB estimates from 32 Alberta lakes of moderate to high primary productivity (mean summer total phosphorus concentration 57 ± 9 $\mu g \cdot L^{-1}$) were regressed against DO concentrations and additional

trophic, morphometric, and water chemistry variables. Minimum open-water DO concentrations explained 38% of the variance in PMB at sites where minimum DO was < 4 mg·L^{-1}, but accounted for no detectable variation when minimum DO was > 4 mg·L^{-1}. Bottom slope (12%) and specific conductivity (4%) increased to 55% the amount of variance explained for PMB at sites where minimum DO was < 4 mg·L^{-1}. Variables indicative of phytoplankton biomass (chlorophyll a, total phosphorus, and Secchi transparency) were nonsignificant in Alberta lakes, suggesting that food was non-limiting for profundal macroinvertebrates in these predominantly eutrophic lakes. These results suggest that DO concentrations hold potential as a predictor of PMB in eutrophic lakes.

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1. General Introduction

The benthic habitat of a lake can be divided into littoral, sublittoral and profundal regions (Jónasson 1978; Wetzel 1983; Walter 1985). The profundal region corresponds roughly to the hypolimnion and is characterized by a relatively homogeneous substrate of fine, highly organic mud (gyttia). The absence of light penetration excludes macrophytes from the profundal region. Water temperatures are cool relative to shallower depths, with low seasonal variation. Hypolimnetic dissolved oxygen concentrations exhibit pronounced seasonal variability and often become periodically depleted in lakes of high primary productivity.

The species diversity of profundal macroinvertebrates (benthic invertebrates $\geq$ 500 µm in length) is low relative to those in the littoral and sublittoral regions because of the harsh environmental conditions and limited choice in habitat (Walter 1985). The profundal community is dominated by macroinvertebrates that feed on detritus (decomposing organic matter), either as deposit or filter feeders (Jónasson 1978; Johnson 1985). Predatory taxa are also present but are either facultative predators or migrate to find prey. The macroinvertebrate taxa most commonly encountered in the profundal region of northern temperate lakes are chironomids, chaoborids and oligochaetes, all of which are specially adapted to cope with the rigours of their habitat.

Since pelagic grazers utilize only a small proportion of total primary production (Johnson 1987), profundal detritivores such as Chironomus spp. and tubificid oligochaetes form an important energy transfer route in lakes, converting large amounts of low-energy detritus into a useable food source for higher trophic levels (Brinkhurst 1974; Jónasson 1978; Hanson and Peters 1984). Extended periods of low dissolved oxygen (DO) concentrations in the hypolimnion and at the sediment-water interface limit profundal macroinvertebrate abundance and biomass in many eutrophic, seasonally stratified lakes and reservoirs (Rawson 1930; Deevey 1941; Brundin 1951; Fast 1971; Cowell et al. 1987). The combined effects of low hypolimnetic DO concentrations and water temperatures, and limited food availability in the profundal region, have a major impact on

macroinvertebrate growth, productivity and population dynamics (Jónasson 1978). Macroinvertebrate abundance in oxygen-limited habitat decreases with increasing depth, and often only anaerobic bacteria are present at the deepest depths (Brundin 1951; Brinkhurst 1974).

The initiation of a hypolimnetic oxygen injection project in Amisk Lake, Alberta, in June 1988 (Prepas et al., In press), provided an opportunity to examine profundal macroinvertebrate community responses to elevated hypolimnetic DO concentrations over a 4 yr period, and to make comparisons with benthic communities from a nearby reference lake of similar morphometry and trophic status. Prior to predicting possible treatment responses, it is necessary to consider how profundal macroinvertebrate populations are influenced by interactions with physical, chemical and biotic factors.

1.1. Factors Affecting Macroinvertebrate Distribution in Lakes

Dissolved Oxygen

Dissolved oxygen profiles in almost all lakes are clinograde during stratification; concentrations are negatively correlated with depth (Wetzel 1983). Hypolimnetic DO concentrations depend on the net balance between processes that remove oxygen (decomposition, respiration and oxidation in the sediments and water column), and processes that add oxygen (photosynthesis and water column circulation; Cornett and Rigler 1987b). Thermal stratification during summer and ice cover during winter greatly impede vertical transport of DO into the hypolimnion; DO demand exceeds oxygen input, and hypolimnetic oxygen depletion occurs. In some lakes the amount of DO removed is small whereas in others complete hypolimnetic anoxia may occur shortly after the onset of stratification. Lakes prone to high hypolimnetic oxygen depletion rates are characterized by extended summer and winter thermal stratification, incomplete water column mixing during turnover, elevated hypolimnetic temperatures, high salinity, a low surface area to volume ratio, large allochthonous inputs, and high primary productivity (Davis 1975; Wetzel 1983; Prepas and Burke, In press).

Organic detritus resulting from primary productivity accumulates in the profundal region, and associated bacterial decomposition can be a major source of DO demand in productive lakes (Jónasson 1964; Rasmussen and Kalff 1987; Takada and Kato 1991). Primary productivity is highest during the summer months, and oxygen depletion is exacerbated by warm hypolimnetic temperatures and strong thermal stratification. Anoxic conditions promote total phosphorus release from the sediments, resulting in late summer cyanobacterial blooms and further detrital inputs (Trimbee and Prepas 1988).

Sediments are a major DO sink in productive lakes because of accumulated reducing compounds and the respiratory demands of associated biota. Most macroinvertebrates inhabit the upper 10 cm of substrate; deeper penetration is possible only under well-oxygenated conditions (Oliver 1971). An upper layer of oxidized material in undisturbed substrate slows DO diffusion from the overlying water into the sediments, but the effectiveness of this barrier is reduced by deposition of fresh detritus and disturbances caused by turnover and bioturbation (van Duyl et al. 1992). Bioturbation promotes sediment DO consumption through increased bacterial activity and direct contact of anoxic mud with oxygenated water (Frenzel 1990; van Duyl et al. 1992; Heinis 1993). Macroinvertebrate respiration may itself create significant DO depletion where biomass is high (Takada and Kato 1991). The oxidized sediment layer thins during stagnation, and a thin layer of anoxic water is created immediately above the sediments; this condition is referred to as microstratification (Mortimer 1941; Brundin 1951). This anoxic layer is present to a limited extent even in oligotrophic lakes, and increases in thickness during periods of high oxygen demand. Substrata-bound macroinvertebrates must either be large-bodied or build tubes extending above the microstratified layer to obtain oxygen (Pinder 1986). If DO concentrations fall below 1 $mg \cdot L^{-1}$, the oxidized layer disappears and the zone of oxygen depletion ascends rapidly through the water column (Brundin 1951).

Chemical oxygen demand from compounds such as humic substances can be a major contributor to oxygen depletion (Juday and Birge 1932). Chemical oxygen demand accounted for approximately 70% of the total oxygen demand at 15 °C in Lake Suwa

sediments (Takada and Kato 1991). Humic substances, along with other compounds such as hydrogen sulfide, methane and ammonia, are also toxic to macroinvertebrates and aggravate oxygen stress (Grimas 1949; Davis 1975; Petersen et al. 1986).

Profundal macroinvertebrates in many deep, productive lakes are limited in abundance and diversity by extended hypoxic or anoxic conditions at the sediment-water interface, whereas the littoral region is subjected to only short-term hypoxia, if at all (Brinkhurst 1974; Jónasson 1978). Changing DO regimes in lakes can result in a restructuring of the macroinvertebrate community, including the invasion of new species, changes in species dominance, or changes in overall densities and biomass (Davis 1975).

Temperature

Hypolimnetic thermal regimes are determined by latitude, altitude, regional weather patterns, and basin morphometry (Wetzel 1983). Water temperatures determine the solubility of oxygen, and regulate biotic and chemical oxygen consumption in lakes (Wetzel 1983; Cornett and Rigler 1987b). Macroinvertebrate growth rates, fecundity, hatching success, and egg development times are dependent on ambient temperatures (Giberson and Rosenberg 1992b; Williams and Feltmate 1992). Temperatures in the profundal region are lower compared to the littoral region; annual and diel variations in the profundal region are low and negligible, respectively (Wetzel 1983; Williams and Feltmate 1992).

Seasonal changes in temperature are more important in regulating macroinvertebrate life cycles than annual thermal maxima and minima (Williams and Feltmate 1992). The degradation of thermal stratification during turnover periods may serve to cue moulting, pupation and emergence activity in profundal insects (Brinkhurst 1974; Pinder 1986). Thus, critical stages in the life cycle can be phased to occur with the appearance of optimal DO concentrations and food materials in the habitat.

Metabolic rates increase directly with temperature, within the upper and lower tolerance thresholds for a particular species (Williams and Feltmate 1992). An increase in hypolimnetic temperatures during summer stagnation exacerbates hypoxic stress directly

by increasing metabolic oxygen demand, and indirectly by promoting bacterial and chemical oxygen consumption (Aston 1973; Pinder 1986). Food quantity and quality can modify growth response to temperature, affecting body weight, fecundity, and developmental timing (Giberson and Rosenberg 1992a). Temperature in turn influences food quantity and quality by influencing phytoplankton production and bacterial activity on detritus (Giberson and Rosenberg 1992a).

In summary, hypolimnetic temperatures are important in determining profundal community structure, but interactions between temperature, hypolimnetic DO and food makes it difficult to examine the effects of temperature separately (Brinkhurst 1974).

Availability of Food

The profundal macroinvertebrate community is heavily dependent on detritus (dead particulate organic matter and its associated microbial decomposers) as a food source (Pomeroy 1980; Wetzel 1983). Approximately 90% of profundal macroinvertebrates are detritivorous (Jónasson 1978), and many profundal carnivores such as tanypodinid chironomids feed on detritus to supplement their diet (Oliver 1971; Pinder 1986). Most detritus originates from primary production in the epilimnion and littoral region, as suggested by the positive correlation between epilimnetic chlorophyll a concentrations and profundal macroinvertebrate biomass (Saether 1979; Rasmussen and Kalff 1987). Allochthonous inputs are also important, particularly near the mouths of rivers and streams (Brinkhurst 1974; Hanson and Peters 1984). Since organic deposits are "funnelled" into deep water by water currents and lake morphometry (Hutchinson 1957), the profundal region has the potential to support a macroinvertebrate standing crop similar to, or surpassing, that of the littoral region (Jónasson 1978). Extremely high densities and biomass of taxa such as Chironomus spp. and tubificids are possible where optimum food, DO and temperatures exist (Brinkhurst 1974; Jónasson 1978; Kajak 1987). However, low hypolimnetic DO concentrations associated with large accumulations of detrital matter keep macroinvertebrate biomass well below carrying capacity in most lakes.

Detrital distribution, sedimentation rates and nutritive quality influence secondary productivity and distribution of macroinvertebrate biomass in the profundal region (Jónasson 1964, 1978). The deposition of detritus depends largely on epilimnetic currents. The largest and heaviest detrital materials are deposited in the littoral region, whereas fine particles remain suspended until they enter the hypolimnion and are deposited in the profundal region (Hutchinson 1957). During overturn periods, detritus from all depths may become resuspended and horizontally displaced (Lastein 1976). Sedimentation rates are inversely proportional to water column mixing, vertical water temperature gradients, and depth (Hutchinson 1957). Rates vary seasonally, with high rates corresponding to peaks in primary productivity (Jónasson 1978). High sedimentation rates in the profundal region result in loose, flocculent substrate with high [DO] demand (Fast 1971; Cowell et al. 1987; Takamura and Iwakuma 1990). The nutritive quality of detritus depends on its origin and degree of decomposition. Spring and autumnal diatom blooms are a higher quality food source than green algae; cyanobacterial detritus is least palatable (Jónasson 1964; Rasmussen 1984; Johnson et al. 1989). The nutritive quality of detritus is negatively correlated with bacterial activity and depth within the substrate (Jónasson 1978; Takada and Kato 1991). Particles suspended in the water column for extended periods, such as in well-mixed or deep lakes, may be completely oxidized before they reach the sediments (Hutchinson 1957; Cornett and Rigler 1987a).

Detritivores are selective in terms of particle size (Jónasson and Kristiansen 1967) and food quality (Johnson et al. 1989). Fresh food, such as living algal cells, is only periodically available and forms a minor portion of the diet, but growth rates of Chironomus with access to fresh food are higher than growth rates for Chironomus feeding on detritus alone (Johnson 1987; Johnson et al. 1989). Decomposer bacteria on detritus may form a direct food source for many detritivores. These bacteria break down many otherwise indigestible compounds to enable consumption by macroinvertebrates (Kajak and Rybak 1966; Nalepa and Thomas 1976; Pinder 1986).

Food is the primary factor determining macroinvertebrate community composition and growth rates when DO concentrations are non-limiting (Saether 1979). Periodic

deposition of new, high-quality food materials provides a feeding stimulus necessary for the larvae of many profundal chironomids to pupate and emerge (Hilsenhoff 1967). Although large accumulations of organic materials in the sediments promote macroinvertebrate productivity, the accompanying bacterial oxygen demand may make feeding on these rich food stores impossible. Extreme eutrophication is often accompanied by a decline in profundal macroinvertebrate biomass, whereas the reversal of eutrophication may cause biomass to increase (Takamura and Iwakuma 1990).

1.2. Characteristics of Profundal Macroinvertebrates

Physiological and Behavioural Adaptations

Although profundal macroinvertebrates have been considered by some to "endure rather than select" their environment (Deevey 1941), they display a range of physiological and behavioural adaptations designed to deal with the oxygen regime of their habitat. Physiological adaptations include the synthesis of the respiratory pigment haemoglobin (Walshe 1950; Brundin 1951; Tichy 1980; Osmulski and Leyko 1986), respiration rates independent of ambient DO concentrations (Berg et al. 1962; Davis 1975; Herreid 1980), and anaerobic metabolism (Frank 1983). Behavioural responses to declining DO concentrations include increased ventilation activity (Walshe 1950; Brundin 1951; Heinis and Crommentuijn 1992) and migration (LaRow 1970; Davies 1976; Heinis et al. 1989).

Haemoglobin is present in many profundal macroinvertebrate taxa, most notably Chironominae and Tubificidae, and forms a major protein constituent of the haemolymph (Aston 1973; Tichy 1980; Osmulski and Leyko 1986). Haemoglobin is absent in taxa such as Orthocladiinae from well-oxygenated habitats (Oliver 1971; Pinder 1986). Haemoglobin and erythrocruorin, a related compound, have a high affinity for oxygen and are effective for oxygen transport and storage at low ambient DO concentrations (Walshe 1950; Osmulski and Leyko 1986). Oxygen is stored in the haemolymph during ventilation activity to maintain aerobic metabolism during feeding and burrowing. The storage period depends on ambient temperatures (Walshe 1950).

Many aspects of haemoglobin use in macroinvertebrates (e.g. interspecific differences in tolerance to hypoxia) are poorly understood. Chironomus does not appear to synthesize haemoglobin in response to declining DO concentrations, unlike the cladoceran Daphnia pulex (Engel 1985). Haemoglobin content does not differ significantly between larvae of the same species of Chironomus from oxygenated and anoxic habitats (Heinis 1993). In addition, Chaoborus and Procladius do not possess haemoglobin but are tolerant of hypoxia (Berg et al. 1962; Oliver and Roussel 1983), whereas Tanytarsus, which possesses haemoglobin, suffers rapid mortality during anoxia (Walshe 1948; Heinis et al. 1989). As an alternative to haemoglobin, chaoborids use their thoracic and abdominal air sacs to aid in oxygen extraction at low concentrations (Pennak 1978). Differences in hypoxic tolerance among chironomids possessing haemoglobin may be a result of interspecific variations in haemoglobin composition; these variations determine its affinity for oxygen (Heinis 1993). Haemoglobin may also buffer the effects of acidic conditions on calcium and sodium regulation; C. plumosus is often the only chironomid present in lakes with pH < 6.0 (Pinder 1986).

Differences in respiratory response to hypoxic conditions are effective in determining species distribution with depth (Jónasson 1978). Crustaceans and insects generally have higher respiratory rates than oligochaetes and molluscs from similar habitats (Hamburger and Dall 1990). Littoral species from well-aerated water have higher metabolic rates than their sublittoral and profundal cogeners, and are thus less tolerant of low DO concentrations (Jónasson 1978); this trend is also evident in comparisons of cogeners from running and stagnant waters (Walshe 1948; Golubkov and Tiunova 1989). Littoral taxa are generally metabolic conformers (respiratory rates vary directly with DO concentrations), whereas profundal taxa are metabolic regulators (respiratory rates are unaffected by a wide gradient of DO concentrations) until a critical minimum DO concentration is reached (Berg et al. 1962; Davis 1975; Herreid 1980). For example, tubificid oxygen consumption is virtually unaffected by declining DO concentrations down to a critical minimum of approximately 9-20% of air saturation (Aston 1973; Jónasson 1978). Chironomus anthracinus respiration has two critical minima: the first occurs at 25%

of air saturation, when respiration rates begin a gradual decline, and the second occurs at 2.5%, when the decline becomes rapid (Jónasson 1978). The relationship between oxygen uptake and DO concentration for sublittoral taxa appears intermediate relative to littoral and profundal taxa, because DO concentrations in the sublittoral region may show considerable fluctuation over the short term. Respiration rates and critical minima for sublittoral species are higher than for closely related species inhabiting the profundal region, and surface feeders (e.g. Chironomus) have higher respiration rates than subsurface feeders (tubificids) (Jónasson 1978). Oxygen consumption by large-bodied individuals tends to be lower and more independent of DO concentrations than that of small-bodied individuals (Herreid 1980), which may partly explain why second- and third-instar Chironomus larvae are restricted to shallower depths relative to fourth instars (Heinis 1993). Respiration rates and critical DO minima increase with increasing temperature, and the respiration rates of species from cool, deep-water habitats begin to increase at lower temperatures than those of cogeners from warm, shallow waters (Bairlein 1989).

In the complete absence of oxygen, all physical activity ceases and essential metabolic processes are maintained anaerobically. The anaerobic breakdown of glycogen produces ethanol as the main end product, which is excreted (Frank 1983). Minor end products include acetate, which is also excreted, and lactate and alanine, which are retained by the body. Anaerobic glycolysis may allow survival in anoxia for weeks to months, depending on the taxa and ambient temperature (Berg et al.1962; Aston 1973; Davis 1975; Nagell and Landahl 1978). However, anaerobic glycolysis cannot continue indefinitely because accumulating toxic byproducts must eventually be processed aerobically (Brundin 1951; Davis 1975). Chironomus anthracinus mortality during anoxia at 4 °C was approximately 20% after 75 days and 100% after 150 days, whereas C. plumosus survived twice as long (Nagell and Landahl 1978). Anaerobic glycolysis may allow increased resistance to the toxic effects of hydrogen sulfide (Nagell and Landahl 1978; Osmulski and Leyko 1986). Survivorship in anoxia decreases with increasing temperatures (Berg et al. 1962; Holopainen 1987).

Macroinvertebrate mortality during anoxia may be caused by starvation before the effects of anaerobiosis become critical. Mortality rates of Chaoborus and Chironomus deprived of food in oxygenated water was similar to those of individuals kept in complete anoxia (Berg et al. 1962; Nagell and Landahl 1978). Anaerobiosis yields less energy per unit of glucose than does aerobic metabolism (Davis 1975); thus, reserves are depleted faster in anoxic than in oxic conditions. Oxygen consumption is usually depressed for some time during recovery from anoxia, while aerobic enzymes altered during anaerobiosis are replaced (Herreid 1980). Interspecific differences in resistance to anoxia among chironomids are dependent on glycogen stores and rates of anaerobic glycolysis (Heinis 1993). Second- and third-instar C. anthracinus larvae are less tolerant of anoxia relative to fourth instars, possibly because the earlier instars require more energy for metabolism and thus deplete their glycogen reserves earlier during anaerobiosis. Prepupal Chaoborus larvae are highly susceptible to mortality from anoxic stress (Sikorowa 1968); oxygen consumption by macroinvertebrates also increases during moulting (Herreid 1980).

Declining DO concentrations induce an increase in ventilation activity in chironomids and oligochaetes. Chironomid larvae position themselves head-first at the mouth of their living tubes and create a water current down the tunnel with undulatory body movements (Brundin 1951; Heinis and Crommentuijn 1992). Most oligochaetes also build sediment tubes; the anterior portion of the body is oriented downwards in the tube and the posterior portion, which may possess gills as in Branchiura, is waved back and forth to circulate the water (Pennak 1978). Ventilation activity brings more DO into contact with the body surface, and also flushes carbon dioxide and excretory wastes from the tube. Ammonium is released at discrete intervals by Chironomus to reduce oxygen demand due to nitrification (Frenzel 1990). Ventilation activity increases at the expense of feeding as hypolimnetic DO concentrations decrease or temperatures increase (Brundin 1951). Profundal species have lower rates of oxygen consumption and therefore spend less time ventilating and have fewer ventilation periods per hour than sublittoral species (Frenzel 1990). At low concentrations (< 1 mg·L^{-1} for C. anthracinus; Jónasson 1978; Heinis and Crommentuijn 1992), feeding ceases entirely and all energy is devoted to

ventilation. With the onset of anoxia, chironomids move downwards into the sediments, suspend all activity to conserve energy, and enter an anaerobic state.

Chironomid migration appears to be stimulated mainly by declining DO concentrations and food resources (Bay et al. 1966; Hilsenhoff 1967; Neubert and Frank 1980; Heinis et al. 1989), although it may also be caused by a search for thermal optima (Deevey 1941). Migratory behaviour has been described for many profundal chironomids (Deevey 1941; Mundie 1959; Oliver 1971; Davies 1976; Heinis et al. 1989). Free-living Tanypodinae larvae use the water column to move about the profundal region (Oliver 1971; Pinder 1986); tube-building Chironominae will also enter the water column occasionally (Davies 1976). Vertical migration into the epilimnion may lead to passive horizontal dispersal by currents and seiches (Mundie 1959; Davies 1976). Many chironomids are displaced during lake overturn and deposited in deeper waters (Lastein 1976; Heinis 1993). Little is known about whether chironomid migration is a random response to deteriorating conditions, or if the larvae can orientate towards better habitat. Positive phototaxis and/or negative geotaxis may guide larvae to shallower, oxygenated depths, and chemotaxis may direct them towards oxygen and food (Davies 1976; Heinis et al. 1989). However, oxygen and light gradients in the profundal region, particularly in large, deep basins, may not be strong enough to guide larvae. Migratory behavior in chironomids may be random at best, with survival being a matter of luck (Deevey 1941; Heinis et al. 1989). The migratory ability of oligochaetes is limited relative to insect larvae, but in Lake Suwa the tubificid Rhyacodrilus migrates downwards into the sediments during the summer to escape rising water temperatures (Takada et al. 1992).

Chaoborus spp. and Mysis relicta are unique in the profundal community in that they exhibit diel vertical migratory behavior (LaRow 1970; Parma 1971; Pennak 1978; Wagner-Döbler 1990). Migration behavior is influenced primarily by light intensity, temperature, and DO concentrations. Changes in light intensity determine whether Chaoborus larvae leave the sediments, but low DO concentrations appear to be a major regulatory factor for vertical migration (LaRow 1970). However, DO concentrations do not appear to influence migration velocity (Wagner-Döbler 1990). Diel vertical migrations

into the epilimnion at night allow Chaoborus to relieve anoxic stress (Walter 1985); using the hypolimnion during the day provides a refugium from fish predation (Parma 1971; Cowell et al. 1987). During turnover periods, both Chaoborus and M. relicta spend daylight hours in the substrate to avoid predators, but low hypolimnetic DO concentrations during the summer may force them to leave the bottom entirely and become pelagic (Fast 1971; Parma 1971; Pennak 1978). Vertical migration and a high tolerance to anoxia allow Chaoborus to inhabit depths too hypoxic for Chironomus or Procladius (Dermott et al. 1977; Sikorowa 1978).

The literature on macroinvertebrate physiological and behavioural responses to hypoxia is confusing, both because a large diversity of responses to hypoxia exists among species and because of the many different methods used to study these responses (Davis 1975; Herreid 1980). Thus, defining exact minimum DO requirements for macroinvertebrate taxa is extremely difficult.

Population Dynamics

Macroinvertebrate distribution in the profundal region is clumped or contagious (Elliott 1977; Downing 1979). Small-scale patchiness in the profundal region, resulting from sediment displacement by deep currents, variations in bottom profile, and bioturbation, is more prevalent than previously believed (Downing and Rath 1988; Lang 1989) and can contribute to high spatial variability in profundal population estimates (Hilsenhoff 1967; Downing 1979). Temporal variation in macroinvertebrate densities can also be high, as a result of mortality, emergence, and migration. However, profundal conditions are more homogeneous and predictable than in the littoral region, and foster simple population dynamics and community structure (Pinder 1986).

Profundal macroinvertebrates have slower growth rates and longer life spans relative to the littoral region (Aston 1973; Jónasson 1978). Growth in profundal chironomids is limited to the spring and fall overturn periods, when phytoplankton production provide fresh surface deposits of detritus and DO concentrations permit feeding (Jónasson 1964, 1978; Johnson and Pejler 1987). Growth may cease during

summer stagnation because hypoxic conditions (< 1 $mg \cdot L^{-1}$ for C. anthracinus; Jónasson 1978) prevent feeding. Weight loss during this period is indicative of starvation (Deevey 1941). Feeding and growth may continue during the winter in an ice-free lake, but stop under ice cover as a result of low DO concentrations and temperatures. Feeding rates in sublittoral-dwelling Chironomus plumosus began to decline at 10 °C and ceased at < 5 °C in Lake Winnebago, Wisconsin (Hilsenhoff 1966), while growth in deep-water C. anthracinus was not limited by winter temperatures of 2.2-4.4 °C in Lake Esrom, Denmark (Jónasson 1970). Most profundal chironomids require 1-2 yr to reach maturity because of extended interruptions in growth. Chironomus anthracinus living below 17 m in Lake Esrom took 2 yr to complete their lifecycle, whereas larvae of the same species at or above the thermocline (14-17 m) completed development in 1 yr (Jónasson 1978). Oligochaete growth is less dependent than chironomid growth on seasonal variation in DO, but a subsurface diet of low energy sediment and cool hypolimnetic temperatures means that tubificids require at least 3-4 yr to reach reproductive maturity in deep, cool-water lakes (Jónasson 1978; Reynoldson 1987).

Development and reproduction, particularly of profundal insects, are closely linked with the replenishment of DO and food during overturn periods (Hilsenhoff 1966, 1967). Larvae that hatch during spring turnover have access to optimum DO and diatom food resources. Growth rates of early-instar insect larvae are more temperature-dependent than late instars. For example, early instars of Chaoborus spend most of their time in the epilimnion, partly to take advantage of warmer water temperatures (Hanazato and Yasuno 1989). Large increases in larval chironomid and chaoborid biomass and transformation into the fourth instar correspond with the return of oxygen during autumnal overturn (Jónasson 1964). Ice-out and spring overturn trigger a final period of larval growth to prepare for pupation, emergence and mating (Pinder 1986; Williams and Feltmate 1992). Some chironomid larvae fail to emerge with the rest of their cohort (Hilsenhoff 1966) and may act as a reserve that buffers the population during periods of unusually harsh conditions during the main emergence (Pinder 1986). Chironomus are highly dependent on spring turnover as a stimulus for pupation and emergence, to the extent that genetically

distinct populations can develop in adjacent water bodies where turnover commences on different dates (Pedersen 1988).

Secondary productivity in the profundal region is low compared to the littoral region as a result of lower food quality, lower mean temperatures and periodic interruption of feeding and growth by hypoxia (Jónasson 1978). However, accumulated biomass can be very high (Jónasson 1978). Faster growth rates in the littoral region mean that most taxa are bi- or multivoltine. Productivity in the profundal region is highest during fall overturn, coinciding with fresh detrital deposits and elevated hypolimnetic temperatures (Johnson and Pejler 1987). Productivity and turnover (P/B) rates of herbivores are higher compared to detritivores; the nutritive value of detritus is low compared to fresh plant tissue and decreases with depth within the substrate (Johnson 1984). Surface-feeding chironomids have periodic access to fresh detritus, but subsurface feeders are limited to degraded matter; within the profundal community, productivity and P/B rates of surface feeders are 10 and 5 times higher, respectively, than in subsurface feeders (Jónasson 1975). Chironomid larval productivity is highest during the fourth instar and corresponds with peaks in primary productivity; most growth occurs during a short, intensive period (Rasmussen 1984).

Hypolimnetic oxygen regimes, food and temperature exert a major influence over feeding, growth and reproduction of macroinvertebrate populations inhabiting the profundal region. Despite these limitations, profundal macroinvertebrates form a primary energy transfer route in lakes (Hanson and Peters 1984); they reclaim phytoplankton biomass that otherwise is lost to the lentic ecosystem and have a higher production efficiency than phytoplankton and zooplankton communities (Deevey 1941; Jónasson 1978; Johnson 1987).

Predation and Competition

Predation has a major impact on macroinvertebrate community structure and productivity in the littoral and sublittoral regions (Brinkhurst 1974; Vodopich and Cowell 1984; Williams and Feltmate 1990) but plays a minimal role in profundal habitat where

DO concentrations are limiting (Kajak 1987). Intra- and interspecific competition is also considered to be low among profundal macroinvertebrates (Pinder 1986). Detritus is a plentiful food source, and species diversity is limited in the profundal region by low habitat diversity, low year-round temperatures, and periodic hypolimnetic anoxia (Walter et al. 1985). Mortality from anoxic stress may be more important in limiting profundal macroinvertebrate populations than predation and competition.

Fish are usually the most important predators of macroinvertebrates in lakes, consuming a large proportion of annual production in the littoral region (Walter et al. 1985; Pinder 1986). However, benthivorous fish are restricted to depths above the thermocline for most of the year by a combination of low hypolimnetic DO concentrations and temperatures. Fish predation on profundal macroinvertebrates is low or negligible during stratification, but predation pressure during overturn periods can be high (Jónasson 1972). Larval chironomids in the profundal region may be inaccessible to predators, but short-term predation on pupae and adults by fish, mysids and birds can be intense (Walter et al. 1985; Pinder 1986). Chaoborus uses the hypoxic hypolimnion as a refuge from fish predation, and is often extirpated after aeration or destratification (Sikorowa 1978; Cowell et al. 1987). Fish and tanypodinids show greater selectivity for surface-feeding chironomids over subsurface oligochates (Sikorowa 1978), and for free-living macroinvertebrates over tube dwellers (Hershey 1986, 1987). Early instars of C. anthracinus are restricted to the upper 2 cm of substrate in the sublittoral and upper profundal regions by their lower tolerance to hypoxia, and are selected more frequently by fish than fourth instars at greater depths (Hershey 1987; Heinis 1993). Subsurface feeders are least susceptible to fish predation, but have to trade-off for higher DO concentrations, better grazing and greater mobility at the surface.

Chaoborids and tanypodinids have a limited predatory influence on the profundal community. Chaoborus will take chironomid and oligochaete prey in the sediments, and may be partly responsible for excluding oligochaetes from the profundal regions of some lakes (Walter et al. 1985). However, Chaoborus is primarily a zooplankton predator (Parma 1971) and may leave the sediments completely during anoxia. Procladius also can

have an important impact on Chironomus spp. and oligochaete populations in the profundal region in some habitats (Hilsenhoff 1967; Dusoge 1980; Hershey 1986; Johnson and Pejler 1987). Although not an obligate carnivore, Procladius need energy derived from animal prey to complete their lifecycles (Hershey 1986). However, Procladius commonly migrates out of the deep profundal region to avoid hypoxia during stagnant periods. Procladius will take larval instars < 5 mm in length but cannot prey effectively on late instars of Chironomus (Hilsenhoff 1967; Dusoge 1980; Hershey 1986).

An indirect predator/prey relationship exists between Chironomus and tubificids; ingestion of egg coccoons by Chironomus decreases during years of emergence and tubificid populations increase accordingly (Jónasson 1978; Vodopich and Cowell 1984). Oligochaetes may disperse as a means of avoiding chironomid predation (Kaster 1989). Chironomus also eat eggs of their own species, eliminating overlapping generations (Jónasson 1972).

Competition in the profundal region is poorly understood, but appears to be minimal because low hypolimnetic DO concentrations limit macroinvertebrate densities and diversity. Specialized foraging habits (i.e. surface vs. subsurface feeding, filter vs. deposit feeding) ensure a minimum overlapping of niches and distribution. Chironomus species have developed staggered emergence periods to minimize competition for food materials among new larvae (Johnson and Pejler 1987). There is some evidence for intraspecific competition for space between C. anthracinus in Lake Esrom (Jónasson 1972), but little information exists on interspecific competition among chironomid species (Pinder 1986). Competition for preferred food and living space would become important only at extremely high densities (Kajak 1987).

Hypoxic conditions force many macroinvertebrate taxa to search for better habitat, increasing their risk from predation (Rahel and Kolar 1990). Macroinvertebrates appear more able to avoid predation by remaining in suboptimal foraging habitat than by remaining in hypoxic habitat. Since species vary in their tolerance to hypoxia, decreasing DO concentrations may lead to selective predation on oxygen-sensitive species and ultimately influence macroinvertebrate species assemblages (Rahel and Kolar 1990). In

habitat where hypolimnetic DO concentrations are non-limiting, food availability, foraging strategies, competition, and predation become important in limiting profundal macroinvertebrate communities (Johnson 1987). Although hypoxia limits species diversity, the exclusion of predators allows densities and biomass of tolerant species to become very high; tubificid densities of a million·m^{-2} are common under hypereutrophic conditions (Aston 1973; Kajak 1987).

1.3. Macroinvertebrate response to hypolimnetic aeration

Hypolimnetic aeration has been used extensively as a lake management technique in Europe and North America over the past 50 yr (Mercier and Perret 1949; Taggart and McQueen 1982; Ashley 1983, 1985). Oxygen is introduced into the hypolimnion during summer and winter stratification to meet the chemical and organic oxygen demand of the sediments and water column. This treatment is primarily used to control nuisance phytoplankton blooms by reducing phosphorus release from the sediments, and to reduce the incidence of fish kills caused by hypolimnetic anoxia (Cowell et al. 1987). Destratification aeration and hypolimnetic aeration are the most widely used forms of aeration (Fast et al. 1975). Destratification aeration vertically mixes the water column during traditional stagnation periods, but causes significant increases in hypolimnetic temperature (> 10 C°; Fast 1971; Cowell et al. 1987), which impact negatively on cool- and cold-water fishes (Overholtz et al. 1977). Current hypolimnetic aeration technology has difficulty maintaining hypolimnetic DO concentrations above 2 mg·L^{-1} during summer stratification, and has problems with vertical mixing in lakes < 15 m in depth (McQueen and Lean 1986). Hypolimnetic oxygenation, which uses pure oxygen rather than air, elevates hypolimnetic DO concentrations with lower volumes of introduced gas, and reduces destratification and sediment disturbance problems (Fast et al. 1975).

Few data exist on the effects of hypolimnetic aeration on profundal macroinvertebrates. Responses to aeration-induced changes in hypolimnetic DO concentrations and water temperatures are variable. Oligochaete and chironomid densities,

biomass and average weight declined during destratification aeration of Section Four Lake, Michigan; there were no significant changes in distribution of macroinvertebrate taxa with depth (Fast 1971). However, hypolimnetic aeration in Hemlock Lake, Michigan, resulted in a doubling of total macroinvertebrate densities and spring chironomid emergence and a 6600% increase in oligochaete densities after one year (Fast 1971). Chironomus rapidly colonized the previously anoxic profundal region, but Ephemeroptera and Odonata remained absent. Overall Chaoborus densities increased and larvae spent more time in the hypolimnion after aeration commenced. Chaoborus species dominance shifted from C. flavicans to C. punctipennis. This suggested that rainbow trout out-competed C. flavicans for Daphnia pulex prey, and C. punctipennis were more efficient predators of Bosmina, which increased in abundance during aeration. Minnow predation reduced macroinvertebrate abundance in the littoral region of both lakes during aeration, but was minimal in the profundal region. Hypolimnetic aeration of small (7 ha) Lake Starodworskie, Poland, resulted in uniform vertical temperature and DO profiles (Sikorowa 1978). Significant increases in macroinvertebrate densities were noted at all depths. Chironomid and oligochaete densities increased at 23 m from 0 to 5000 and 9000 individuals$\cdot m^{-2}$, respectively, but C. flavicans almost disappeared. Macroinvertebrate densities, biomass and number of taxa increased in the profundal region of most of the lakes in 9 destratification and aeration studies (Pastorok et al. 1980). Habitat expansion and shifts in macroinvertebrate community structure provided an increased food base for fish; dominance possibly shifted towards benthivorous fish species. Chaoborus populations declined in treated lakes as a result of the removal of hypolimnetic refugia from fish predation; dominance shifted towards chironomid and oligochaete taxa. Exceptions such as Parvin Lake (Lackey 1973) exhibited significant reductions in oligochaete and chironomid densities and biomass. These were attributed to water column mixing that stimulated mass chironomid emergence and promoted fish predation. Destratification aeration in Lake Brooker, Florida (Cowell et al. 1987) also resulted in a 10-fold reduction in C. punctipennis, either because of a loss of anoxic refugia from fish predation or a shift in their zooplankton food source from small- to large-bodied species. Total numbers of

macroinvertebrate taxa in Lake Brooker increased from 12 to 55 over the 2 yr aeration period; chironomids formed 70% of the total density.

Previous aeration studies that included macroinvertebrates were relatively short-term (2-3 yr), in small (< 14 ha), relatively shallow (< 15 m) bodies of water (Dinsmore and Prepas, In press); reference systems for comparison were not included. Therefore, a study of long-term treatment (> 3 yr) and comparison to separate, untreated reference basins is desirable. Also, an evaluation of community response in relation to other limnological parameters would provide a valuable contribution to our general understanding of energy flow through lake sediments and to future lake management programmes using similar technology.

1.4. Projected Long-term Impacts of Hypolimnetic Oxygenation

Most studies associated with hypolimnetic oxygenation projects are primarily concerned with water quality (Bianucci and Bianucci 1979) or survival of cold-water fish (Overholtz et al. 1977). Projections of expected profundal macroinvertebrate response to hypolimnetic oxygenation should be of interest to fisheries managers considering this treatment method because the maintenance of expanded fisheries habitat in the hypolimnion will depend on whether adequate food resources are available.

Hypoxia-tolerant taxa already present in the profundal region will be the first to respond to elevated hypolimnetic DO concentrations, and will also be the first to colonize previously uninhabitable depths. Insect larvae, particularly chironomids, will respond before oligochaetes, based on their faster growth and dispersal (Fast 1971; Sikorowa 1978). Elevated DO concentrations would improve survivorship, and allow feeding to continue during stratification. An extended feeding period would enable individual growth rates and weights to increase, and reduce or eliminate mortality and emigration. A larger larval body size improves tube ventilation efficiency (Heinis 1993), and makes it easier to obtain oxygen above the microstratified layer (Brundin 1951; Heinis 1993). Larger larvae produce larger adults, and possibly higher reproductive success; for example, fecundity in

C. cucini is positively correlated with female body weight (Butler and Walker 1992). Increased hypolimnetic temperatures caused by water column destratification can lead to faster growth rates and smaller body size (Fast 1971; Oliver 1971), but hypolimnetic oxygenation is expected to preserve thermal stratification (Prepas et al., In press). Tubificids dominate habitats where accumulated organic matter and oxygen demand is high (Aston 1973; Nalepa and Thomas 1976), but compete poorly in habitats where Chironomus are present (Jónasson 1978). Elevated hypolimnetic DO concentrations may shift dominance from tubificids to Chironomus in the profundal community. Fish predation would increase in the profundal region during aeration, but its impact would be offset by increased secondary productivity.

Several workers noted that shallow water taxa occurred in the deep profundal regions of large lakes, either as a result of migration or displacement by currents moving off-shore (Rawson 1930; Davies 1976; Lastein 1976). Also, Chironomus larvae appear in the deepest areas of the profundal region during overturn, but cannot survive extended anoxia during stagnation (Heinis 1993). Hypolimnetic oxygenation may help sustainable populations of oxygen-sensitive taxa to establish in the upper profundal region and maintain populations of hypoxia-tolerant taxa at deeper depths. Chironomids can rapidly invade new habitat through aerial dispersion of adults, planktonic dispersion of first-instar larvae, and migration of later instars (Fast 1971; Davies 1976; Cowell 1984). Increased Chironomus spp. burrowing and tube-building activity help to oxidize anaerobic sediments and retard the re-suspension of organic material during overturn, reducing oxygen demand (Fast 1971; Jónasson 1978). As profundal macroinvertebrate densities increase, increased respiration and bioturbation increase oxygen demand and phosphorus release, which may reach critical levels during stagnation (Ripley 1980; Fukuhara and Sakamoto 1987; Tatrai 1988; Takada and Kato 1991; Heinis 1993). However, one or more years commonly elapse after commencement of treatment before chironomid and oligochaete responses are evident (Fast 1971; Cowell et al. 1987), so the investigator may have to monitor the profundal community for several years before the impact of treatment can be adequately assessed.

As hypolimnetic DO regimes are altered by hypolimnetic oxygenation, profundal macroinvertebrate community structure should also change in a manner that is representative of responses in other oxygenation projects. The results then can be used as a model to predict future treatment results.

1.5. Study Sites

The first whole-lake hypolimnetic oxygenation project in North America commenced in June 1988 in the north basin of Amisk Lake, in central Alberta. The primary goals of this project were to reduce the incidence of summer cyanobacterial blooms and to enhance sport fish habitat (Prepas et al., In press).

Amisk Lake (54°35'N 112°37'W), located 175 km northeast of Edmonton, is a naturally eutrophic (mean summer chlorophyll a concentration (1980-1987): 8.7-25.4 $mg \cdot L^{-1}$), hardwater lake with a water residence time of 8 yr (Prepas and Trew 1983; Prepas 1990a). Approximately 88% of the drainage basin is forested. Agricultural use is limited to 4% of the drainage basin and development around the lake is limited to two moderately sized cottage subdivisions and a trailer camp on the north basin. The lake is divided into two distinct basins: a north basin (surface area = 2.33 km^2, Z_{max} = 34 m), which is connected by a narrows (maximum sill depth = 13 m) to a larger, deeper south basin (surface area = 2.82 km^2, Z_{max} = 60 m). Both basins thermally stratify during the summer; thermoclines are situated at 5 to 10 m in depth. Historically, incomplete hypolimnetic mixing during spring and fall turnover and high epilimnetic primary production during summer resulted in high hypolimnetic oxygen depletion rates (in summer 1980, 0.691 and 0.628 g $O_2 \cdot m^{-2} \cdot d^{-1}$, north and south basins respectively) below the thermocline that led to late summer and winter anoxia below 10 m (Babin 1984; Prepas 1990a). The littoral region of Amisk Lake extends from 0 to 4 m, the sublittoral from 4 to 10-12 m, and the profundal from 10-12 m to maximum depth. The profundal region constitutes the majority of the benthic habitat (~ 40% of the north basin and ~ 60% of the south basin). No pretreatment data existed for the profundal macroinvertebrate

communities of Amisk Lake, although 7 yr of background data on water quality were available from both basins (Prepas and Burke, In press). Sampling in May 1988, before hypolimnetic oxygenation was scheduled to begin, indicated that Chironomus spp. was the most common taxon in the profundal regions of both basins. Chironomus spp., Oligochaeta (Tubificidae), Procladius spp. and Chaoborus spp. comprised > 90% of the total profundal macroinvertebrate densities of both basins (Dinsmore and Prepas 1993).

The oxygen delivery system consisted of a liquid oxygen storage tank onshore, a vapourizer and ~ 1 km of weighted rubber hose. Pure oxygen entered the hypolimnion from a diffuser situated in the deep hole (34 m) of the north basin ~ 1 m above the sediments. The south basin of Amisk Lake was not treated and served as a reference system. The oxygen delivery system injected oxygen at rates of 0.2 to 1.3 tonnes·d^{-1} from 1988 to 1993 (Prepas et al., In press). An extensive survey of limnological parameters was undertaken in conjunction with the hypolimnetic oxygenation project; researchers participated from the University of Alberta, National Water Research Institute (Burlington, ON), Limnofix (Calgary, AB), Alberta Fish and Wildlife, and Praxair Ltd. (Edmonton, AB).

The south basin of Baptiste Lake (54°45'N 113°33'W) was chosen as a second, independent reference basin. This lake is situated 165 km northwest of Edmonton and approximately 75 km west of Amisk Lake. It is morphometrically similar to Amisk Lake but is more productive; it is a hypereutrophic (mean summer chlorophyll a concentrations (1980-1987): 13.4-50.9 mg·L^{-1}), hardwater lake with a water residence time of 6 yr (Prepas and Trew 1983; Prepas 1990b). Approximately 80% of the drainage basin of Baptiste Lake is forest and wetlands, but it has more agricultural, residential and recreational development in its watershed and around its shoreline than at Amisk Lake. Baptiste Lake is also divided into two distinct basins: a north basin (surface area = 5.07 km^2, Z_{max} = 15.5 m), connected by a narrows (maximum sill depth = 6 m) to a deeper south basin (surface area = 4.74 km^2, Z_{max} = 27.5 m). The south basin also thermally stratifies during the summer (thermoclines occur between 5 and 10 m) and incompletely mixes during the spring and autumn. As in Amisk Lake, high hypolimnetic oxygen

depletion rates (in winter 1982-1983: 0.775 g $O_2 \cdot m^{-2} \cdot d^{-1}$) result in anoxia throughout most of the summer, autumn and winter below 10 m (Babin 1984; Prepas 1990b). The depth boundaries of the littoral, sublittoral and profundal regions are similar to Amisk Lake (see above); the profundal region of the south basin of Baptiste Lake accounts for ~ 75% of the total bottom area. No historical data were available for the profundal macroinvertebrate communities of Baptiste Lake; profundal samples collected in the south basin in May 1988 contained mostly Chaoborus flavicans, which comprised > 97% of profundal macroinvertebrates collected at sites deeper than 15 m (Dinsmore and Prepas, In press).

1.6. Objectives

I monitored the profundal macroinvertebrate communities of the treated north and untreated south basins of Amisk Lake, and the south basin of Baptiste Lake, from May to November of 1988 to 1991 inclusive. My research objectives were to compare changes in profundal macroinvertebrate abundance, biomass and diversity between the treated basin of Amisk Lake and the reference basins, and to relate these changes to trends in hypolimnetic DO concentrations and temperatures. Chapter 2 describes changes in abundance and diversity of major benthic taxonomic groups in response to hypolimnetic oxygenation in Amisk Lake. Chironomus spp. (Diptera: Chironomidae) were the numerically dominant macroinvertebrates in Amisk Lake. Chapter 3 examines changes in abundance and biomass of Chironomus species in response to hypolimnetic oxygenation. Chapter 4 evaluates, using empirical models, the effectiveness of hypolimnetic DO concentrations as a predictor of profundal macroinvertebrate biomass in eutrophic lakes. Finally, Chapter 5 summarizes the conclusions of this project and makes suggestions for future research.

1.7. References

Ashley, K.I. 1983. Hypolimnetic aeration of a naturally eutrophic lake: physical and chemical effects. Can. J. Fish. Aquat. Sci. 40: 1343-1359.

Ashley, K.I. 1985. Hypolimnetic aeration: practical design and application. Water Res. 19: 735-740.

Aston, R.J. 1973. Tubificids and water quality: a review. Environ. Pollut. 5: 1-10.

Babin, J. 1984. Winter oxygen depletion in temperate zone lakes. M.Sc. Thesis, University of Alberta, Edmonton, AB.

Bairlein, F. 1989. The respiration of Chironomus-larvae (Diptera) from deep and shallow waters under environmental hypoxia and at different temperatures. Arch. Hydrobiol. 115: 523-536.

Bay, E.C., A.A. Ingram, and L.D. Anderson. 1966. Physical factors influencing chironomid infestation of water-spreading basins. Ann. Entomol. Soc. Am. 59: 714-717.

Berg, K., P.M. Jónasson, and K.W. Ockelmann. 1962. The respiration of some animals from the profundal zone of a lake. Hydrobiologia 19: 1-40.

Bianucci, G., and E.R. Bianucci. 1979. Oxygenation of a polluted lake in northern Italy. Effluent and Water Treat. 19: 117-128.

Brinkhurst, R.O. 1974. The Benthos of Lakes. MacMillan Press, London. 190 p.

Brundin, L. 1951. The relation of oxygen-microstratification at the mud surface to the ecology of the profundal bottom fauna. Inst. Freshwater Res. Drottningholm 32: 32-42.

Butler, M.G., and L. Walker. 1992. Fecundity, reproductive effort, and pupal size in the profundal midge Chironomus cucini (Diptera: Chironomidae). Neth. J. Aquat. Ecol. 26: 263-267.

Cornett, R.J., and F.H. Rigler. 1987a. Decomposition of seston in the hypolimnion. Can. J. Fish. Aquat. Sci. 44: 146-151.

Cornett, R.J., and F.H. Rigler. 1987b. Vertical transport of oxygen into the hypolimnion of lakes. Can. J. Fish. Aquat. Sci. 44: 852-858.

Cowell, B.C. 1984. Benthic recolonization of small-scale disturbances in the littoral zone of a subtropical Florida lake. Hydrobiologia 109: 193-205.

Cowell, B.C., C.J. Dawes, W.E. Gardiner, and S.E. Scheda. 1987. The influence of whole lake aeration on the limnology of a hypereutrophic lake in central Florida. Hydrobiologia 148: 3-24.

Davies, B.R. 1976. The dispersal of Chironomidae larvae: a review. J. Ent. Soc. Sth. Afr. 39: 39-62.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. J. Fish. Res. Board Can. 32: 2295-2332.

Deevey, E.S. 1941. Limnological studies in Connecticut. VI. The quantity and composition of the bottom fauna of thirty-six Connecticut and New York lakes. Ecol. Monogr. 11: 413-455.

Dermott, R.M., J. Kalff, W.C. Leggett, and J. Spence. 1977. Production of Chironomus, Procladius and Chaoborus at different levels of phytoplankton biomass in Lake Memphremagog, Quebec-Vermont. J. Fish. Res. Board Can. 34: 2001-2007.

Dinsmore, W.P., and E.E. Prepas. 1993. Changes in macroinvertebrate diversity in a deep eutrophic lake undergoing hypolimnetic oxygen injection, with particular reference to Chironomus spp. (Chironomidae). Verh. Internat. Verein. Limnol. 25: 302-306.

Dinsmore, W.P., and E.E. Prepas. In press. The impact of hypolimnetic oxygenation on profundal macroinvertebrates of a eutrophic lake in central Alberta. I. Changes in macroinvertebrate abundance and diversity. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Downing, J.A. 1979. Aggregation, transformation, and the design of benthos sampling programs. J. Fish. Res. Board Can. 36: 1454-1463.

Downing, J.A., and L.C. Rath. 1988. Spatial patchiness in the lacustrine sedimentary environment. Limnol. Oceanogr. 33: 447-458.

Dusoge, K. 1980. The occurrence and role of the predatory larvae of Procladius Skuse (Chironomidae, Diptera) in the benthos of Lake Sniardwy. Ekol. Pol. 28: 155-186.

Elliot, J.M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates. Scientific publ. #25. 2nd ed. Freshwater Biol. Assoc. 156 p.

Engle, D. 1985. The production of haemoglobin by small pond Daphnia pulex: intraspecific variation and its relations to habitat. Freshwater Biol. 15: 631-638.

Fast, A.W. 1971. The effects of artificial aeration on lake ecology. Ph.D. Thesis, Michigan State Univ., E. Lansing MI.

Fast, A.J., W.J. Overholtz, and R.A. Tubb. 1975. Hypolimnetic oxygenation using liquid oxygen. Water Resour. Res. 11: 294-299.

Frank, C. 1983. Ecology, production and anaerobic metabolism of Chironomus plumosus L. larvae in a shallow lake. II. anaerobic metabolism. Arch. Hydrobiol. 96: 354-362.

Frenzel, P. 1990. The influence of chironomid larvae on sediment oxygen microprofiles. Arch. Hydrobiol. 119: 427-438.

Fukuhara, H., and M. Sakamoto. 1987. Enhancement of inorganic nitrogen and phosphate release from lake sediment by tubificid worms and chironomid larvae. Oikos 48: 312-320.

Giberson, D.J., and D.M. Rosenberg. 1992a. Effects of temperature, food quantity, and nymphal rearing density on life-history traits of a northern population of Hexagenia (Ephemeroptera: Ephemeridae). J. N. Am. Benthol. Soc. 11: 181-193.

Giberson, D.J., and D.M. Rosenberg. 1992b. Egg development in Hexagenia limbata (Ephemeroptera: Ephemeridae) from Southern Indian Lake, Manitoba: temperature effects and diapause. J. N. Am. Benthol. Soc. 11: 194-203.

Golubkov, S.M., and T.M. Tiunova. 1989. Dependence of the respiration rate upon oxygen concentration in water for rheophilous mayfly larvae (Ephemeroptera). Aquatic Insects 11: 147-151.

Grimas, U. 1949. The bottom fauna of Lake Vattern, Central Sweden, and some effects of eutrophication. Inst. Freshwater Res. Drottningholm 49: 49-62.

Hamburger, K., and P.C. Dall. 1990. The respiration of common benthic invertebrate species from the shallow littoral zone of Lake Esrom, Denmark. Hydrobiologia 199: 117-130.

Hanazato, T., and M. Yasuno. 1989. Effect of temperature in laboratory studies on growth of Chaoborus flavicans (Diptera: Chaoboridae). Arch. Hydrobiol. 114: 497-504.

Hanson, J.M. and R.H. Peters. 1984. Empirical predictions of crustacean zooplankton and profundal macrobenthos biomass in lakes. Can. J. Fish. Aquat. Sci. 41: 439-445.

Heinis, F. 1993. Oxygen as a factor controlling occurrence and distribution of chironomid larvae. Ph.D. Thesis, Universiteit van Amsterdam, Amsterdam, The Netherlands.

Heinis, F., and T. Crommentuijn. 1992. Behavioral responses to changing oxygen concentrations of deposit feeding chironomid larvae (Diptera) of littoral and profundal habitats. Arch. Hydrobiol. 124: 173-185.

Heinis, F., W.J. van de Bund, and C. Davids. 1989. Avoidance of low oxygen and food concentrations by the larvae of Tanytarsus sp. Acta Biol. Debr. Oecol. Hung. 3: 141-145.

Herreid, C.F. 1980. Hypoxia in invertebrates. Comp. Biochem. Physiol. 67: 311-320.

Hershey, A.E. 1986. Selective predation by Procladius in an arctic Alaskan lake. Can. J. Fish. Aquat. Sci. 43: 2523-2528.

Hershey, A.E. 1987. Tubes and foraging behavior in larval Chironomidae: implications for predator avoidance. Oecologia 73: 236-241.

Hilsenhoff, W.L. 1966. The biology of Chironomus plumosus (Diptera: Chironomidae) in Lake Winnebago, Wisconsin. Ann. Entomol. Soc. Am. 59: 465-473.

Hilsenhoff, W.L. 1967. Ecology and population dynamics of Chironomus plumosus (Diptera: Chironomidae) in Lake Winnebago, Wisconsin. Ann. Entomol. Sci. Am. 60: 1183-1194.

Holopainen, I.J. 1987. Seasonal variation in survival time in anoxic water and the glycogen content of Sphaerium corneum and Pisidium amnicum (Bivalvia, Pisidiidae). Am. Malacol. Bull. 5: 41-48.

Hutchinson, G.E. 1957. A Treatise on Limnology. Vol. I. Geography, Physics and Chemistry. John Wiley and Sons, London and New York. 1015 p.

Johnson, R.K. 1984. Distribution of Chironomus plumosus and C. anthracinus with respect to sediment parameters in mesotrophic Lake Erken. Verh. Internat. Verein. Limnol. 22: 750-758.

Johnson, R.K. 1985. Feeding efficiencies of Chironomus plumosus (L.) and C. anthracinus Zett. (Diptera: Chironomidae) in mesotrophic Lake Erken. Freshwater Biol. 15: 605-612.

Johnson, R.K. 1987. Seasonal variation in diet of Chironomus plumosus (L.) and C. anthracinus Zett. (Diptera: Chironomidae) in mesotrophic Lake Erken. Freshwater Biol. 17: 525-532.

Johnson, R.K., and B. Pejler. 1987. Life histories and coexistence of the two profundal Chironomus species in Lake Erken, Sweden. Ent. Scand. Suppl. 29: 233-238.

Johnson, R.K., B. Boström, and W. van de Bund. 1989. Interactions between Chironomus plumosus (L.) and the microbial community in surficial sediments of a shallow, eutrophic lake. Limnol. Oceanogr. 34: 992-1003.

Jónasson, P.M. 1964. The relationship between primary production and production of profundal bottom invertebrates in a Danish eutrophic lake. Verh. Int. Verein. Limnol. 15: 471-479.

Jónasson, P.M. 1970. Population studies on Chironomus anthracinus. Proc. Adv. Study Inst. Dynamics Numbers Popul. (Oosterbeck, 1970): 220-231.

Jónasson, P.M. 1972. Ecology and production of the profundal benthos in relation to phytoplankton in Lake Esrom. Oikos Suppl. 14: 1-148.

Jónasson, P.M. 1975. Population ecology and production of benthic detritivores. Verh. Int. Verein. Limnol. 19: 1066-1072.

Jónasson, P.M. 1978. Zoobenthos of lakes. Verh. Int. Verein. Limnol. 20: 13-37.

Jónasson, P.M., and J. Kristiansen. 1967. Primary and secondary production in Lake Esrom. Growth of Chironomus anthracinus in relation to seasonal cycles of phytoplankton and dissolved oxygen. Internat. Rev. Ges. Hydrobiol. 52: 163-217.

Juday, C., and E.A. Birge. 1932. Dissolved oxygen and oxygen consumed in the lake waters of northeastern Wisconsin. Trans. Wisc. Acad. Sci. Arts Lett. 27: 415-486.

Kajak, Z. and J.I. Rybak. 1966. Production and some trophic dependencies in benthos against primary production and zooplankton production in several Masurian lakes. Verh. Int. Verein. Limnol. 16: 441-451.

Kajak, Z. 1987. Determinants of maximum biomass of benthic Chironomidae (Diptera). Ent. Scand. Suppl. 29: 303-308.

Kaster, J.L. 1989. Observations of predator-prey interaction on dispersal of an oligochaete prey, Limnodrilus hoffmeisteri. Hydrobiologia 180: 191-193.

Lackey, R.T. 1973. Bottom fauna changes during artificial reservoir destratification. Water Res. 7: 1349-1353.

Lang, C. 1989. Effects of small-scale sedimentary patchiness on the distribution of tubificid and lumbriculid worms in Lake Geneva. Freshwater Biol. 21: 477-481.

LaRow, E.J. 1970. The effect of oxygen tension on the vertical migration of Chaoborus larvae. Limnol. Oceanogr. 15: 357-362.

Lastein, E. 1976. Recent sedimentation and resuspension of organic matter in eutrophic Lake Esrom, Denmark. Oikos 27: 44-49.

McQueen, D.J., and D.R.S. Lean. 1986. Hypolimnetic aeration: an overview. Water Poll. Res. J. Can. 21: 205-217.

Mercier, P., and J. Perret. 1949. Station d'aeration au lac de Bret. Schweiz. Verein. Gas. Wasserfach. Monatsbull 29: 25-30.

Mortimer, C.H. 1941. The exchange of dissolved substances between mud and water in lakes. J. Ecol. 29: 280-329.

Mundie, J.H. 1959. The diurnal activity of the larger invertebrates at the surface of Lac la Ronge, Saskatchewan. Can. J. Zool. 37: 945-956.

Nagell, B., and C.C. Landahl. 1978. Resistance to anoxia of Chironomus plumosus and Chironomus anthracinus (Diptera) larvae. Holarct. Ecol. 1: 333-336.

Nalepa, T.F., and N.A. Thomas. 1976. Distribution of macrobenthic species in Lake Ontario in relation to sources of pollution and sediment parameters. J. Great Lakes Res. 2: 150-163.

Neubert, I., and C. Frank. 1980. Response of chironomid fauna after autumn overturn in an eutrophic lake. pp. 283-290. In D.A. Murray [ed.] Chironomidae: ecology, systematics, cytology and physiology. Pergamon Press, Oxford, UK. 354 p.

Oliver, D.R. 1971. Life history of the Chironomidae. Ann. Rev. Entomol. 16: 211-230.

Oliver, D.R., and M.E. Roussel. 1983. The insects and arachnids of Canada Part 11: The genera of larval midges of Canada (Diptera: Chironomidae). Biosystematics Research Institute, Ottawa. 263 p.

Osmulski, P.A., and W. Leyko. 1986. Structure, function and physiological role of Chironomus haemoglobin. Comp. Biochem. Physiol. 85B: 701-722.

Overholtz, W.J., A.W. Fast, R.A. Tubb, and R. Miller. 1977. Hypolimnion oxygenation and its effects on the depth distribution of rainbow trout (Salmo gairdneri) and gizzard shad (Dorosoma cepedianum). Trans. Am. Fish. Soc. 106: 371-375.

Parma, S. 1971. Chaoborus flavicans (Meigen) (Diptera, Chaoboridae): an autecological study. Ph.D. Thesis, Rijksuniversiteit te Groningen, Rotterdam, the Netherlands.

Pastorok, R.A., T.C. Ginn, and M.W. Lorenzen. 1980. Review of aeration/circulation for lake management. p. 124-133. In Restoration of Lakes and Inland Waters. EPA 440/5-81-010. U.S. Envir. Prot. Ag., Washington D.C.

Pedersen, B.V. 1988. Mechanisms underlying the stable co-existence of two genetically distinct populations of Chironomus plumosus (Diptera: Chironomidae) in Lake Tystrup-Bavelse, Denmark. Holarct. Ecol. 11: 106-110.

Pennak, R.W. 1978. Freshwater invertebrates of the United States. 2nd. ed. J. Wiley & Sons, NY. 803 p.

Petersen, R.C. Jr., L.M. Petersen, U. Persson, A. Kullberg, A. Hargeby, and A. Paarlberg. 1986. Health aspects of humic compounds. Water Qual. Bull. 11: 44-62.

Pinder, L.C.V. 1986. Biology of freshwater Chironomidae. Ann. Rev. Entomol. 31: 1-23.

Prepas, E.E. 1990a. Baptiste Lake. p. 122-130. In P. Mitchell and E.E. Prepas [ed.] Atlas of Alberta Lakes. University of Alberta Press, Edmonton, AB.

Prepas, E.E. 1990b. Amisk Lake. p. 225-231. In P. Mitchell and E.E. Prepas [ed.] Atlas of Alberta Lakes. University of Alberta Press, Edmonton, AB.

Prepas, E.E., and J.M. Burke. In press. Hypolimnetic oxygen injection as a method of improving water quality in lakes with large internal inputs of phosphorus. Can. J. Fish. Aquat. Sci. 00: 0000-0000.

Prepas, E.E., K.M. Field, T.P. Murphy, W.L. Johnson, and W.M. Tonn. In press. Introduction to the Amisk Lake project: oxygenation of a deep eutrophic lake. Can. J. Fish. Aquat. Sci. 00:0000-0000.

Prepas, E.E., and D.O. Trew. 1983. Evaluation of the phosphorus-chlorophyll relationship for lakes off the Precambrian Shield in western Canada. Can. J. Fish. Aquat. Sci. 40: 27-35.

Pomeroy, L.R. 1980. Detritus and its role as a food source. pp. 84-102. In Barnes, R.S.K., and K.H. Mann. [ed.] Fundementals of aquatic ecosystems. Blackwell Sci. Publ., Oxford, UK.

Rahel, F.J., and C.S. Kolar. 1990. Trade-offs in the response of mayflies to low oxygen and fish predation. Oecologia 84: 39-44.

Rasmussen, J.B. 1984. The life history, distribution and production of Chironomus riparius and Glyptotendipes paripes in a prairie pond. Hydrobiologia 119: 65-72.

Rasmussen, J.B., and J. Kalff. 1987. Empirical models for zoobenthic biomass in lakes. Can. J. Fish. Aquat. Sci. 44: 990-1001.

Rawson, D.S. 1930. The bottom fauna of Lake Simcoe and its role in the ecology of the lake. Univ. Toronto Stud. Biol. Ser. 34: 1-183.

Reynoldson, T.B. 1987. The role of environmental factors in the ecology of tubificid oligochaetes - an experimental study. Holarct. Ecol. 10: 241-248.

Ripley, M.P. 1980. The relation of dry weight and temperature to respiration in some benthic chironomid species in Lough Neagh. pp. 81-88. In D.A. Murray [ed.]

Chironomidae: ecology, systematics, cytology and physiology. Pergamon Press, Oxford, UK.

Saether, O.A. 1979. Chironomid communities as water quality indicators. Holarct. Ecol. 2: 65-74.

Sikorowa, A. 1968. The behavior of Chaoborus Licht. larvae under unfavourable oxygen concentrations. Ekol. Pol. 16: 185-191.

Sikorowa, A. 1978. Changes of the distribution and number of the bottom fauna as an effect of artificial lake aeration. Verh. Internat. Verein. Limnol. 20: 1000-1003.

Taggart, C.T., and D.J. McQueen. 1982. A model for the design of hypolimnetic aerators. Water Res. 16: 949-956.

Takada, K., and K. Kato. 1991. Benthic oxygen consumption in Lake Suwa. Verh. Internat. Verein. Limnol. 24: 1091-1094.

Takada, K., K. Kato, and T. Okino. 1992. Environmental parameters and estivation of Rhyacodrilus (Tubificidae, Oligochaeta) in Lake Suwa, Japan. Ecography 15: 328-333.

Takamura, K., and T. Iwakuma. 1990. Fate of macrobenthos in hypereutrophic lakes: in situ rearing experiments with the larvae of Tokunagayusurika akamusi (Chironomidae). Arch. Hydrobiol. 119: 65-78.

Tatrai, I. 1988. Experiments on nitrogen and phosphorus release by Chironomus ex gr. plumosus from the sediments of Lake Balaton, Hungary. Int. Revue ges. Hydrobiol. 73: 627-640.

Tichy, H. 1980. The haemoglobin synthesising tissue of Chironomus. pp.43-50. In D.A. Murray [ed.] Chironomidae: ecology, systematics, cytology and physiology. Pergamon Press, Oxford, UK.

Trimbee, A.M., and E.E. Prepas. 1988. The effect of oxygen depletion on the timing and magnitude of blue-green algal blooms. Verh. Internat. Verein. Limnol. 23: 220-226.

van Duyl, F.C., A.J. Kop, A. Kok, and A.J.J. Sandee. 1992. The impact of organic matter and macrozoobenthos on bacterial and oxygen variables in marine sediment boxcosms. Neth. J. Sea Res. 29: 343-355.

Vodopich, D.S., and B.C. Cowell. 1984. Interaction of factors governing the distribution of a predatory aquatic insect. Ecology 65: 39-52.

Wagner-Döbler, I. 1990. Vertical migration of Chaoborus flavicans (Diptera, Chaoboridae): control of onset of migration and migration velocity by environmental stimuli. Arch. Hydrobiol. 117: 279-307.

Walshe, B.M. 1948. The oxygen requirements and thermal resistance of chironomid larvae from flowing and still waters. J. Expt. Biol. 25: 35-44.

Walshe, B.M. 1950. The function of haemoglobin in Chironomus plumosus under natural conditions. J. Exp. Biol. 27: 73-95.

Walter, R.A. 1985. Benthic macroinvertebrates, p. 204-228. In G.E. Likens [ed.] An ecosystem approach to aquatic ecology: Mirror Lake and its environment. Springer-Verlag, NY.

Walter, R.A., R.E. Moeller, D.L. Strayer, and J.J. Cole. 1985. The profundal region, p. 317-322. In G.E. Likens [ed.] An ecosystem approach to aquatic ecology: Mirror Lake and its environment. Springer-Verlag, NY.

Wetzel, R.G. 1983. Limnology. 2nd ed. Saunders College Publ. N.Y. 767 p.

Williams, D.D., and B.W. Feltmate. 1992. Aquatic insects. CAB International, Wallingford, UK. 358 p.

2. Impact of hypolimnetic oxygenation on profundal macroinvertebrates in a eutrophic lake in central Alberta. I. Changes in macroinvertebrate abundance and diversity.[1]

2.1. Introduction

Dissolved oxygen (DO) concentrations, particularly at the sediment-water interface, are of primary importance in determining abundance and diversity of macroinvertebrate communities in the profundal regions of eutrophic lakes and reservoirs (Brundin 1951; Jónasson 1978). Hypolimnetic DO concentrations are inversely related to trophic status (Cornett and Rigler 1987). Oligotrophic and mesotrophic lakes, which have low hypolimnetic DO demands, typically have diverse profundal communities of oxygen-sensitive species, whereas eutrophic lakes have less-diverse communities of anoxia-tolerant species (Brinkhurst 1974; Saether 1979). Reproduction and growth of profundal macroinvertebrates in eutrophic lakes often coincide closely with spring and fall overturn and maximum primary production (Jónasson 1978); conversely, feeding and growth cease during periods of anoxia (DO concentrations < 1 $mg \cdot L^{-1}$), contributing to high mortality rates (Nagell and Landahl 1978; Reynoldson 1987). Seasonal accumulations of organic detritus in the profundal regions of eutrophic lakes can support extremely high densities and biomasses of taxa such as Chironomus spp. and Tubificidae when DO is not limiting (Kajak 1987); however, periods of anoxia related to incomplete hypolimnetic mixing and high rates of detrital decomposition in deep eutrophic lakes can limit the ability of profundal macroinvertebrates to exploit this vast food resource (Fast 1971; Takamura and Iwakuma 1990). Oxygenating the hypolimnion of eutrophic lakes should reduce anoxic stress in profundal macroinvertebrate communities, resulting in increased survival, growth and reproduction. Theoretically, this should allow oxygen-sensitive taxa to inhabit the profundal region year-round.

Hypolimnetic aeration has been widely used in the management of eutrophic lakes in

[1] This chapter is currently in press. W.P. Dinsmore and E.E. Prepas. 1996. Can. J. Fish. Aquat. Sci. vol. 53.

North America (e.g. Fast 1971; Ashley 1983, 1985; McQueen and Lean 1986). Profundal macroinvertebrate responses to increased hypolimnetic DO concentrations have been variable, but have typically involved increases in diversity and density of chironomids and oligochaetes, along with reduction or elimination of Chaoborus spp. populations (Fast 1971; Sikorowa 1978; Pastorok et al. 1980; Cowell et al. 1987). However, few data exist on the effects of hypolimnetic aeration on profundal macroinvertebrate communities in large, deep lakes. Previous studies that included macroinvertebrates (Table 2.1) were short term (1-3 yr) and conducted in small, relatively shallow lakes (mean surface area: 13.4 ha; mean Z_{max}: 14.3 m). Many profundal species living at depths > 15 m in north-temperate lakes have lifespans > 2 yr (Jónasson 1978), so an aeration project of longer duration (> 3 yr) is necessary to observe significant profundal macroinvertebrate community response to increased hypolimnetic DO concentrations. In previous aeration studies, the largest increases in numbers of macroinvertebrate taxa and densities occurred at the greatest depths, where extended periods of anoxia existed before treatment (Sikorowa 1978; Cowell et al. 1987). Thus, macroinvertebrate community response to hypolimnetic oxygenation in Amisk Lake was expected to be greatest at depths > 20 m, where anoxic conditions prevailed for most of the open-water season. It was also expected that increased DO concentrations would affect shallower depths less, because anoxic conditions were less prevalent there.

The objectives of this project were to (1) compare changes in profundal macroinvertebrate densities and diversity between the treated basin of Amisk lake and reference conditions, and (2) relate these changes to trends in hypolimnetic DO concentrations and water temperatures over 4 yr (1988 to 1991).

2.2. Methods

Measurement of Hypolimnetic Dissolved Oxygen and Temperature

Hypolimnetic oxygenation of the north basin of Amisk Lake (North Amisk), located in central Alberta (54°35'N 112°37'W), commenced on 1 June 1988 (Prepas and Burke, In press). North Amisk is joined to the deeper south basin (South Amisk) by a connecting narrows

approximately 13 m deep (Fig. 2.1). Baptiste Lake (54°45'N 113°33'W), located approximately 80 km west of Amisk Lake, also has two basins (Fig. 2.2); the south basin (South Baptiste) is morphometrically similar to North and South Amisk, but has higher primary productivity (Table 2.1). Open-water (May to early November) hypolimnetic DO concentrations and temperatures in North and South Amisk were measured at the deepest site of each basin at 2- to 4-wk intervals from May to August (1980 to 1987), or weekly from May to August and every 2 wk from September until freeze-up (1988 to 1991). Hypolimnetic pre-treatment DO and temperature data from 1980, 1981, 1982 and 1987, when all three basins were monitored concurrently, were averaged, whereas data from each treatment year (1988 to 1991) were considered separately. Open-water hypolimnetic DO concentrations and temperatures in South Baptiste were measured at the deepest site (25 m) monthly from May to August (1980 to 1989), monthly from September until freeze-up (1988 and 1989), or weekly from May to August and every 2 wk from September until freeze-up (1990 and 1991).

Water for hypolimnetic DO analysis was collected at 1-m intervals and analysed following Carpenter's (1965) modification of the Winkler DO method or recorded *in situ* with a YSI Model 57 DO/temperature meter. Hypolimnetic temperature profiles were taken simultaneously at 1-m intervals with a Montedoro-Whitney Model TC-5C thermistor or YSI Model 57 meter. In North and South Amisk, hypolimnetic volume-weighted DO concentrations and temperatures were calculated from data collected from depths of 12 to 18 m, 17 to 23 m, and 22 to 28 m, hereafter referred to as 15, 20 and 25 m, respectively. These depth intervals corresponded to intervals chosen for sampling profundal macroinvertebrates. In South Baptiste, volume-weighted DO concentrations and temperatures for 25 m were calculated from depths of 22 to 25 m.

Statistical comparisons of hypolimnetic volume-weighted DO concentrations and temperature data between lake basins per sampling stratum and treatment year were made with paired *t*-tests, blocking for sampling date; the number of sampling dates paired (*n*) ranged between 17 and 28 for pre-treatment- and between 7 and 22 for treatment-year comparisons. In view of the large number of statistical comparisons made (45 each for DO and temperature), a probability level of $P=0.01$ was assigned to reduce the possibility of committing a type I

error. In addition, hypolimnetic DO and temperature data from each treatment year were compared to pre-treatment data within each basin per stratum, and data from the first year of treatment (1988) were compared to those collected during the fourth year of treatment (1991). Comparisons were made with t-tests modified for samples with heterogeneous variances, using a probability level of P=0.01. Pre-treatment data were collected from early May until mid- to late August, so a similar time frame was used on data collected during treatment years for the analysis; n ranged from 17 to 28 for pre-treatment- and 4 to 17 for treatment-year comparisons.

Profundal Macroinvertebrate Distribution and Abundance

Profundal macroinvertebrates were collected at stations established in North and South Amisk and South Baptiste at 15, 20, and 25 m (Figs. 2.1, 2.2). The depth strata represent the upper, mid- and deep profundal regions, respectively, of the three basins. Sampling stations were established at locations where morphometry and depth were comparable among the three basins. Sampling effort in each basin from 1988 to 1991 is summarized in Table 2.2. From 1988 to 1990, sites were sampled every 2 wk from the beginning of May until the end of August, and monthly from the beginning of September until freeze-up (early November). In 1991, sites were sampled on three dates in May and every 2 wk thereafter from June until late October. Stations were also sampled at 30 m in North and South Amisk using the same frequency as the shallower stations in 1988 but only once a month in 1991 (Table 2.2). Sampling of the three basins during each cycle was completed in ~ 5 d. Two replicates per sampling station were obtained with a tall Ekman grab (15 × 15 × 23 cm) fitted with a 500-µm mesh top screen. Samples were sieved through a 500-µm mesh and preserved in 4% formalin. Samples were later sorted in the laboratory and all macroinvertebrates were stored in 4% formalin, except for molluscs, which were transferred to 70% ETOH to prevent shell deterioration.

Macroinvertebrates were sorted and identified to the taxonomic levels indicated in Table 2.3. These were grouped into five main taxonomic groups for statistical analyses: Chironomus spp., other chironomids, Oligochaeta, Chaoborus spp., and other

macroinvertebrate taxa (Dinsmore and Prepas 1993). Taxa diversity (H') for each study year was calculated for the upper profundal (15 m) and deep profundal (25 m) of each basin using the Shannon-Weaver index (Shannon and Weaver 1949), which takes into account the number of taxa present and their relative abundances. Equitability (J) was calculated using the formula: $J = H' / \ln S$, where S equals the number of taxa present. Mean densities$\cdot m^{-2}$ per depth interval and date were estimated for the main taxonomic groups present in each basin. Also, mean open-water (May to early November) densities$\cdot m^{-2} \pm$ SE were calculated based on all sampling dates of each study year. Densities of Chironomus spp., the most abundant taxon in Amisk Lake, were compared between basins per depth interval with paired t-tests; n ranged between 9 and 13 from 1988 to 1991. A probability level of $P=0.01$ was assigned to avoid type I errors caused by multiple comparisons. The other main taxonomic groups occurred only sporadically, so they were not compared statistically.

2.3. Results

Hypolimnetic DO Concentrations and Temperature

During pre-treatment years (1980-1987), hypolimnetic DO concentrations in both basins of Amisk Lake averaged 4 mg$\cdot L^{-1}$ at 15 m and 2 mg$\cdot L^{-1}$ at 25 m after ice-out, but were < 0.5 mg$\cdot L^{-1}$ below 15 m by late July (Fig. 2.3). Pre-treatment hypolimnetic DO concentrations in South Amisk were higher at 15 and 20 m from May to July than in North Amisk ($P < 0.01$) but were similar at 25 m ($P > 0.57$). Pre-treatment DO concentrations in South Baptiste (Fig. 2.3) averaged 4 mg$\cdot L^{-1}$ at 15 m and < 0.5 mg$\cdot L^{-1}$ at 25 m from early to mid-May, and were 0 mg$\cdot L^{-1}$ at all sampling depths by early July. Pre-treatment hypolimnetic DO concentrations in South Baptiste from May to July were lower than in either basin of Amisk Lake at 20 and 25 m ($P < 0.01$) but were comparable to North Amisk at 15 m ($P > 0.02$).

After the initiation of hypolimnetic oxygenation, open-water hypolimnetic DO concentrations in North Amisk were higher relative to pre-treatment years (Fig. 2.3). Open-water DO concentrations at 25 m in North Amisk remained > 1 mg$\cdot L^{-1}$ throughout the study period, except for approximately 3-5 wk from late August to late September. Hypolimnetic

DO concentrations for each treatment year in North Amisk were higher relative to pre-treatment data for all strata ($P < 0.001$), except for 15 m during 1988 ($P > 0.02$). Mean August hypolimnetic DO concentrations in North Amisk at 25 m, which were < 0.1 $mg \cdot L^{-1}$ during pre-treatment years, reached 0.8 ± 0.2 and 1.6 ± 0.1 $mg \cdot L^{-1}$ in 1988 and 1989, respectively; in comparison, mean August DO concentrations in South Amisk at 25 m remained < 0.3 $mg \cdot L^{-1}$ during the same period. Oxygen delivery efficiency was low in 1988 and 1989 compared to subsequent years (Prepas and Burke, In press). Gradual improvements in the oxygen delivery system allowed the introduction of greater amounts of oxygen into the water column of North Amisk during 1990 and 1991, so that 1991 hypolimnetic DO concentrations in North Amisk were higher relative to 1988 for all sampling depths ($P < 0.01$). However, it became apparent in 1990 that oxygenated hypolimnetic water from North Amisk was being transferred into South Amisk (Lawrence et al., In press). Hypolimnetic DO concentrations at 25 m in South Amisk in 1988 and 1989 were similar to pre-treatment levels ($P > 0.13$) but became significantly higher in 1990 and 1991 ($P < 0.01$). Hypolimnetic DO concentrations in South Amisk in 1991 were higher than in 1988 ($P < 0.01$) at all sampling depths. Although hypolimnetic DO concentrations in South Amisk increased during 1990 and 1991, hypolimnetic DO concentrations remained higher in North Amisk ($P < 0.01$) at all depths for the duration of the study. Mean August hypolimnetic DO concentrations at 25 m in North Amisk during 1990 and 1991 were 1.6 ± 0.3 and 1.5 ± 0.1 $mg \cdot L^{-1}$, respectively, compared to 1.0 ± 0.3 and 0.4 ± 0.02 $mg \cdot L^{-1}$, respectively, at 25 m in South Amisk. Trends in hypolimnetic DO concentrations in South Baptiste (Fig. 2.3) during the study period remained similar to those during pre-treatment years ($P > 0.03$); water at 25 m was anoxic as early as mid-May and remained so until turnover in late October.

Hypolimnetic water temperatures at 20 and 25 m were different among the three basins during pre-treatment years ($P < 0.01$); North Amisk had the highest water temperatures, followed by South Baptiste and South Amisk, although absolute differences were small (< 1.7°C; Fig. 2.4). No differences in pre-treatment hypolimnetic temperatures were noted among basins at 15 m ($P > 0.10$). Convective currents caused by hypolimnetic oxygenation resulted in increased temperatures at all sampling depths in North Amisk relative to previous

years. Treatment did not disrupt thermal stratification during the open-water season, although it did enhance spring mixing (Webb et al., In press). Mean August hypolimnetic temperature at 25 m in North Amisk increased from a pre-treatment average of 6.7°C to > 8°C during the study. However, treatment-year hypolimnetic temperatures in North Amisk were significantly higher only at 20 and 25 m during 1989 ($P < 0.01$) and for all strata during 1990 ($P < 0.001$), relative to pre-treatment data. Temperatures measured during the treatment years 1988 and 1991 were similar for all strata ($P > 0.29$). The large increase in hypolimnetic temperatures in North Amisk during 1990 occurred in conjunction with greater than average wind conditions, which possibly enhanced mixing (Prepas and Burke, In press). Similarly, depressed hypolimnetic temperatures in 1991 coincided with calmer than average conditions.

Water temperatures at 20 and 25 m in South Amisk appeared to be unaffected by the transfer of warmer water from North Amisk during 1990 and 1991 (Fig. 2.4). The larger volume of cool (4 to 6°C) water in the hypolimnion of South Amisk ($33.2 \cdot 10^6$ m^3; Prepas 1990a) relative to North Amisk ($8.2 \cdot 10^6$ m^3) possibly moderated water temperatures at these depths. Mean August temperatures at 25 m were higher in 1989 (6.2 ± 0.03°C) and lower in 1991 (4.2 ± 0.1°C) relative to pre-treatment (5.0 ± 0.2°C) temperatures. Hypolimnetic temperatures at 20 and 25 m in South Amisk were significantly higher in 1989 and 1990 than in pre-treatment years ($P < 0.01$) but lower in 1991 ($P < 0.01$); 1991 temperatures were also significantly lower than 1988 at the same depths ($P < 0.001$).

Hypolimnetic water temperatures at 25 m in South Baptiste followed trends similar to those of South Amisk (Fig. 2.4). Mean hypolimnetic temperatures were similar between South Amisk and South Baptiste at all depths during the study period ($P > 0.05$), except for 25 m during 1989 ($P < 0.01$) and 15 m during 1991 ($P < 0.001$). August temperatures at 25 m in South Baptiste were also highest in 1989 (7.0 ± 0.1°C) and lowest in 1991 (4.7 ± 0.1°C) compared to pre-treatment (6.1 ± 0.3°C) temperatures. Hypolimnetic temperatures in South Baptiste during 1988 ($P > 0.10$) and 1990 ($P > 0.54$) were similar to pre-treatment temperatures at all depths but temperatures during 1989 and 1991 were significantly higher ($P < 0.01$) and lower ($P < 0.001$), respectively, than pre-treatment temperatures at all depths. Similarities in trends between South Amisk and South Baptiste suggest that regional weather

conditions were important factors affecting year-to-year variation in hypolimnetic temperatures; hypolimnetic water temperatures in all three study basins were lower in 1991 compared to other treatment years.

Profundal Macroinvertebrate Distribution and Abundance

In 1988, the profundal macroinvertebrate communities of North and South Amisk were dominated numerically by Chironomus spp. and Oligochaeta at 15 and 20 m and by Chironomus spp. at 25 m (Fig. 2.5; Table 2.3); all taxonomic groups were uncommon at 30 m in both basins. In South Baptiste, Chaoborus flavicans, Oligochaeta and Chironomus spp. were dominant at 15 m, whereas C. flavicans was dominant at 20 and 25 m (Fig. 2.5; Table 2.3). Profundal Chironomus spp. abundance increased at all sampling depths in both North and South Amisk from 1989 through to 1991. Oligochaete densities also increased in Amisk Lake at 15 and 20 m, but to a lesser extent. Dominance of the major taxonomic groups did not change in either basin of Amisk Lake during hypolimnetic oxygenation. Total densities of Chaoborus spp., chironomid genera other than Chironomus spp. and other macroinvertebrate taxa remained low in both basins throughout the treatment period (mean densities were < $200 \cdot m^{-2}$ and < $120 \cdot m^{-2}$ at 15 and 25 m, respectively) and decreased from 33% (1988) to 4% (1991) of all macroinvertebrates collected at 25 m in North Amisk (Table 2.3). No new taxa colonized the profundal region during the study period. Similarly, no new Chironomus species appeared in Amisk Lake, although dominance shifted from C. decorus to C. anthracinus (Dinsmore and Prepas 1993, In press).

In 1988, profundal Chironomus spp. densities were relatively low in all three basins (Fig. 2.5) and did not differ significantly between North and South Amisk ($P > 0.11$ at 15, 20 and 25 m) or between North Amisk and South Baptiste ($P > 0.06$ at 15, 20 and 25 m). As oxygenation progressed, Chironomus spp. densities at all depths in North and South Amisk increased considerably compared to similar depths in South Baptiste and to 1988 estimates (Fig. 2.5). Mean open-water densities of Chironomus spp. were highest during 1991 in both basins of Amisk Lake at all sampling depths. In contrast, Chironomus spp. in South Baptiste during 1991 were rare at all depths. Densities in South Amisk were significantly higher ($P <$

0.01) compared to North Amisk at 15 m from 1989 to 1991 and at 20 m during 1991. Although densities of Chironomus spp. at 25 m were higher in North versus South Amisk from 1989 to 1990 ($P < 0.01$), overall differences between the two basins were not significant during 1991 ($P > 0.51$).

Chaoborus punctipennis and C. flavicans were identified in Amisk Lake, whereas collections from South Baptiste contained only C. flavicans. In Amisk Lake, C. punctipennis comprised 60-90% at 15 m and 55-80% at 25 m of all Chaoborus spp. collected. Mean open-water densities of Chaoborus spp. in North and South Amisk were < $60 \cdot m^{-2}$ at all sampling intervals from 1988 to 1991 (Fig. 2.5). No appreciable changes in Chaoborus spp. densities were noted in either North or South Amisk over the study period. Densities of C. flavicans in South Baptiste were higher than in Amisk Lake and fluctuated substantially with life history (Fig. 2.5). Although densities of Chaoborus spp. were low in North Amisk throughout the study, they did not appear to be adversely affected by hypolimnetic oxygenation.

Oligochaeta were represented primarily by Tubificidae; Stylaria lacustris (Naididae) was also collected from all basins but made up < 1% of Oligochaeta by density (WPD, unpubl. data). Densities of Oligochaeta were highest at 15 m in all three basins and declined sharply as sampling depth increased (Fig. 2.5). Overall, densities in the three basins appeared to follow similar trends during the study period; they declined in 1990 relative to 1989, then increased during 1991, reaching maximum levels for the study. Oligochaeta remained scarce or absent from the deep profundal region (25 m), even after 4 yr of treatment.

Chironomid genera other than Chironomus spp. made up < 9% of all macroinvertebrates collected in North and South Amisk during the study and < 6% in South Baptiste (Table 2.3). Most of these chironomids were Procladius spp. (P. culiciformis and P. ruris), but several other chironomid genera were collected (Table 2.3; Dinsmore and Prepas 1993). No appreciable changes in densities of these chironomid genera were noted in North Amisk during the treatment period.

Ephemeroptera, Trichoptera and Sphaeriidae formed the majority of "other macroinvertebrate taxa" (Fig. 2.5; Table 2.3), but were recorded only sporadically at the depths sampled. Densities of these taxa usually made up < 3% of the totals in Amisk and Baptiste

lakes over the duration of the study. No definite trends appeared for these macroinvertebrates during the study period.

Diversity and equitability indices (H' and J) for 15 and 25 m decreased over the treatment period in all lake basins because of the overwhelming predominance of Chironomus spp. in Amisk Lake and C. flavicans in Baptiste Lake (Table 2.3). Although numbers of taxa were higher at 25 m in North Amisk from 1989 to 1991 relative to 1988, most of the taxa were collected infrequently.

2.4. Discussion

The Amisk Lake study was unique relative to previous studies because it involved a large, double-basined lake, and compared results from long-term treatment (4 yr) to trends in separate, untreated reference basins. In previous studies, profundal macroinvertebrate diversity, abundance and biomass usually responded positively to hypolimnetic aeration, particularly in the deep regions of treated water bodies (Fast 1971; Sikorowa 1978; Pastorok et al. 1980; Cowell et al. 1987). However, significant reductions in oligochaete and chironomid densities and biomass were reported in two lakes (Section Four: Fast 1971; Parvin: Lackey 1973). In these lakes, increased bottom temperatures and DO concentrations caused by water-column mixing possibly stimulated mass chironomid emergence and resulted in the loss of anoxic refugia from fish predation (Fast 1971).

Hypolimnetic aeration in Lake Brooker maintained bottom DO concentrations above 3 $mg \cdot L^{-1}$ year-round, resulting in a doubling of deep-water taxa after 2 yr of treatment (Cowell et al. 1987). It was not possible to achieve similar DO concentrations in North Amisk because of its larger hypolimnetic volume relative to Lake Brooker and the transfer of oxygenated water into South Amisk. Although little is known about specific ranges of preferred DO in freshwater macroinvertebrates, hypolimnetic DO concentrations in North Amisk were probably still too low to allow oxygen-sensitive taxa to colonize the profundal region. The homogeneous profundal habitat of large basins provides limited choice for potential colonizers from shallower depths, especially non-detritivorous taxa. Water temperature, light penetration and substrate

quality in the profundal region of Amisk Lake differed from those of shallower depths. Hypolimnetic water temperatures increased significantly during the summer in North Amisk but remained lower than in the littoral and sublittoral regions. Light penetration remained < 1% below 8 m in North Amisk throughout the study period (EEP, unpubl. data), excluding macrophytes and the taxa that would colonize them. The profundal sediments of Amisk Lake were silty and flocculent, excluding tube- and case-building taxa that prefer firmer, larger-grained substrates (Fast 1971). Although a variety of non-profundal taxa was collected in the profundal regions of North and South Amisk, their combined densities were typically low ($< 80 \cdot m^{-2}$) and they occurred only intermittently. Shallow-water taxa are sometimes displaced into the deep profundal regions of large lakes by off-shore currents (Davies 1976; Lastein 1976), but probably survive in the profundal region for only a short time.

Profundal macroinvertebrate diversity decreased during treatment in Amisk Lake because of the large increase in Chironomus spp. abundance, which was unmatched by other macroinvertebrate taxa. This suggests that the changes in conditions brought about by hypolimnetic oxygenation were favourable only to Chironomus spp. Feeding and growth in C. anthracinus and C. plumosus can be maintained at DO concentrations as low as 1 $mg \cdot L^{-1}$ (Jónasson 1978; Heinis 1993). After treatment, DO concentrations remained > 1 $mg \cdot L^{-1}$ at 25 m for longer periods during the open-water season in both basins of Amisk Lake relative to pre-treatment years; Chironomus spp. could maintain populations year-round in the deep profundal region because mortality from anoxic stress was reduced.

Hypolimnetic DO concentrations at 20 and 25 m did not differ significantly among North Amisk, South Amisk and South Baptiste during pre-treatment years. Similarly, differences in deep profundal Chironomus spp. densities were undetectable among basins during 1988, the treatment year that most closely approximated pre-treatment conditions in all three basins. Hypolimnetic oxygenation resulted in significant increases in deep profundal DO concentrations in both North and South Amisk and this was eventually accompanied by major increases in Chironomus spp. populations. At the same time, conditions in the profundal region of South Baptiste remained unacceptable for macroinvertebrates other than C. flavicans; densities of Chironomus spp. in South Baptiste actually declined from 1988 to 1991. It appears

unlikely that changes in Chironomus spp. populations in Amisk Lake were part of a regional trend.

Chaoborus spp. populations are often reduced or eliminated in aerated lakes (e.g., Sikorowa 1978; Pastorok et al. 1980; Cowell et al. 1987). It has been suggested that Chaoborus spp. populations are decimated by fish predation when anoxic refugia in the hypolimnion are lost, or that large-bodied zooplankton prey preferred by Chaoborus are replaced by smaller-bodied taxa (Cowell et al. 1987). However, no discernable changes were noted in C. flavicans or C. punctipennis densities in North or South Amisk during the study period; densities were low at all sampling depths relative to South Baptiste. Populations of cisco (Coregonus artedi), the primary planktivorous fish in Amisk Lake, avoided depths with DO concentrations < 1.3 $mg \cdot L^{-1}$, but sought depths with DO concentrations of 3.1 ± 1.3 $mg \cdot L^{-1}$ and mean temperatures of $11.8 \pm 2.1°C$ (Aku et al., In press). As a result, cisco were uncommon below 13 m in both basins. Also, the two most common, large-bodied hypolimnetic zooplankters in Amisk Lake, Daphnia longiremis and D. pulex, increased in abundance relative to pre-treatment estimates in the deep hypolimnion of North Amisk during 1989, whereas smaller epilimnetic species such as D. galeata mendotae and Diaptomus oregonensis appeared to be unaffected by treatment (Field and Prepas, In press). Thus, increased predation by fish and increased numbers of large zooplankters, two of the conditions that coincided with declining Chaoborus spp. populations in other aerated lakes, did not materialize in Amisk Lake. Densities of C. flavicans were much higher in South Baptiste relative to North Amisk but declined in South Baptiste at all sampling depths during 1991. Neither the larger population of Chaoborus spp. in South Baptiste relative to Amisk Lake nor the 1991 decline can be explained.

Tubificids were rarely collected below 20 m in Amisk Lake or below 15 m in South Baptiste. Tubificids often exist at high densities in eutrophic water bodies too anoxic for other macroinvertebrates (Aston 1973), so it is likely that factors such as water temperature and sediment quality limited their distribution in the profundal regions of the study basins. Tubificid growth, sexual maturity and reproduction are limited by low hypolimnetic temperatures in the profundal regions of deep, cool-water lakes (Aston 1973; Reynoldson 1987). Oligochaete

populations would be slow to adapt to changes in their habitat because their reproductive output and dispersal rates are low relative to Chironomus spp. Furthermore, predatory/competitive interactions with Chironomus spp. are potentially important in limiting oligochaete populations in habitats already occupied by Chironomus spp. (Jónasson 1978).

One of the primary goals of the hypolimnetic oxygenation project in Amisk Lake was to enhance the existing sports fishery. A greatly enlarged macroinvertebrate food base in the profundal regions of North and South Amisk was an essential prerequisite for achieveing that goal. Although oxygen conditions were enhanced sufficiently to allow profundal Chironomus spp. abundance to increase > 5-fold in both basins of Amisk Lake (Dinsmore and Prepas, In press), it appeared that only the upper profundal region of North Amisk was accessible to fish as foraging grounds (Aku et al., In press). Profundal macroinvertebrates at depths > 13 m were protected from predation by hypoxic conditions that persisted in the deep hypolimnion; they were subject to predation only during overturn periods or chironomid emergence events. However, the large increase in the macroinvertebrate food base in the upper profundal region of North Amisk could conceivably support a greatly expanded fish community. Depressed densities of macroinvertebrates at 15 m in North Amisk relative to similar depths in South Amisk and to deeper depths in North Amisk (Dinsmore and Prepas, In press) suggest that fish were already exploiting this area.

In summary, hypolimnetic oxygenation year-round in North Amisk did not increase DO concentrations in the profundal region sufficiently to allow colonization throughout the region by oxygen-sensitive taxa. The positive response of Chironomus spp. to hypolimnetic oxygenation was similar in North and South Amisk, suggesting that the transfer of oxygenated water from North Amisk also improved conditions for Chironomus spp. in South Amisk. However, Chironomus spp. densities in South Amisk increased without a significant increase in hypolimnetic temperatures, suggesting that temperature is not a primary factor limiting profundal Chironomus spp. populations in Amisk Lake. This study demonstrates the importance of long-term data collection, particularly in the profundal regions of large, cool-water lakes, where macroinvertebrates having extended life spans may require several years of oxygen treatment before they respond.

Table 2.1. Characteristics of lake-aeration studies that included benthic macroinvertebrates. The south basins of Amisk and Baptiste lakes were reference basins for this study. N/A = data were not available. ----- = not applicable.

Lake	Surface area (ha)	Maximum depth (m)	Pre-treatment chl a ($\mu g \cdot L^{-1}$)	Study duration (yr)			Source
				Pre-treatment	Treatment	Post-treatment	
Section Four, MI	1.2	19.1	2	1	0.3	0	Fast 1971
Hemlock, MI	2.4	18.6	2.5	1	0.3	0	Fast 1971
Parvin, CO	19	10	N/A	1	1	0	Lackey 1973
Ham's, OK	40	10	N/A	0	1	0	Wilhm & McClintock 1978
Starodworskie, Poland	7	23	N/A	1	1.5	0.5	Sikorowa 1978
Brooker, FL	10.5	5.2	53.1	1.25	2	0	Cowell et al. 1987
Amisk, AB (north basin)	233	34	17	8	4	0	Prepas 1990a; this study
Amisk , AB (south basin)	282	60	18	-----	-----	-----	Prepas 1990a; this study
Baptiste, AB (south basin)	474	27.5	47.5	-----	-----	-----	Prepas 1990b; this study

Table 2.2. Benthic macroinvertebrate sampling effort for Amisk and Baptiste lakes, 1988-1991.

Depth (m)	Number of sampling stations per year											
	Amisk (north basin)				Amisk (south basin)				Baptiste (south basin)			
	1988	1989	1990	1991	1988	1989	1990	1991	1988	1989	1990	1991
15	6	4	2	1	2	4	2	1	2	4	2	1
20	5	4	3	2	2	4	3	2	2	4	3	2
25	2	2	5	2	2	2	9	2	2	2	9	2
30	2	-----	-----	1	2	-----	-----	1				
Total no. of grabs collected	340	216	220	160	196	216	308	158	102	212	288	117

Table 2.3. Total numbers and % of total of profundal macroinvertebrate taxa collected from 15 m (upper profundal) and 25 m (lower profundal) from the north and south basins of Amisk Lake (North and South Amisk, respectively) and the south basin of Baptiste Lake (South Baptiste), during the open-water season (May-November), 1988-1991. n = the total number of Ekman grabs collected. H' = index of diversity; J = equitability. Blanks indicate no individuals of a particular taxon were collected for that depth and year.

North Amisk

	1988				1989				1990				1991			
	15 m (n = 121)		25 m (n = 40)		15 m (n = 80)		25 m (n = 44)		15 m (n = 44)		25 m (n = 110)		15 m (n = 24)		25 m (n = 59)	
Taxon	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total
Chironomus spp.	2702	0.63	103	0.67	2669	0.57	632	0.77	1606	0.61	2433	0.88	934	0.39	3388	0.94
Other Chironomid Genera	160	0.04	24	0.16	61	0.01	21	0.03	97	0.04	119	0.04	70	0.03	88	0.02
Procladius spp.	125	0.03	23	0.15	42	0.01	18	0.02	78	0.03	80	0.03	66	0.03	83	0.02
Tanytarsus sp.	11	< 0.01			12	< 0.01			8	< 0.01	13	< 0.01	4	< 0.01	3	< 0.01
Ablabesmyia sp.	2	< 0.01			2	< 0.01			2	< 0.01	8	< 0.01				
other genera	22	0.01	1	0.01	5	< 0.01	3	< 0.01	9	< 0.01	18	0.01			2	< 0.01
Chaoborus spp.	110	0.03	24	0.16	39	0.01	40	0.05	47	0.02	118	0.04	19	0.01	29	0.01
C. punctipennis	85	0.02	13	0.08	34	0.01	24	0.03	33	0.01	75	0.03	13	0.01	16	< 0.01
C. flavicans	25	0.01	11	0.07	5	< 0.01	16	0.02	14	0.01	43	0.02	6	< 0.01	13	< 0.01
Oligochaeta	1263	0.30			1778	0.38	111	0.13	857	0.32	29	0.01	1341	0.57	62	0.02
Other Taxa	41	0.01	2	0.01	148	0.03	21	0.03	45	0.02	66	0.02	9	< 0.01	44	0.01
Hydra sp.	11	< 0.01			26	0.01	1	< 0.01	2	< 0.01	8	< 0.01	1	< 0.01	25	0.01
Mermithidae	17	< 0.01			71	0.02	5	0.01	26	0.01	27	0.01	3	< 0.01	9	< 0.01
Hirudinea											1	< 0.01				
Amphipoda	5	< 0.01	2	0.01	5	< 0.01	5	0.01			4	< 0.01			1	< 0.01
Ephemeroptera							1	< 0.01	3	< 0.01	3	< 0.01			1	< 0.01
Haliplidae	1	< 0.01														
Ceratopogonidae	4	< 0.01			4	< 0.01	3	< 0.01			2	< 0.01				
Hydracarina	2	< 0.01			22	< 0.01	4	< 0.01	4	< 0.01	9	< 0.01	1	< 0.01	2	< 0.01
Gastropoda									1	< 0.01	12	< 0.01				
Sphaeriidae	1	< 0.01			20	< 0.01	2	< 0.01	9	< 0.01			4	< 0.01	6	< 0.01
Total organisms	4276		153		4695		825		2652		2765		2373		3611	
Mean density per Ekman grab	35.3		3.8		58.7		18.8		60.3		25.1		98.9		61.2	
Number of taxa	15		6		14		13		14		16		10		13	
Index of diversity (H')	0.97		1.04		0.95		0.90		0.99		0.63		0.87		0.34	
Equitability (J)	0.36		0.58		0.36		0.35		0.37		0.23		0.38		0.13	

Table 2.3. (cont.)

South Amisk

Taxon	1988				1989				1990				1991			
	15 m (n = 40)		25 m (n = 40)		15 m (n = 80)		25 m (n = 44)		15 m (n = 44)		25 m (n = 198)		15 m (n = 24)		25 m (n = 56)	
	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total
Chironomus spp.	1411	0.46	100	0.48	4110	0.59	87	0.62	3933	0.72	2907	0.84	2364	0.67	2863	0.95
Other Chironomid Genera	109	0.04	20	0.10	96	0.01	12	0.09	84	0.02	209	0.06	31	0.01	34	0.01
Procladius spp.	64	0.02	15	0.07	58	0.01	8	0.06	44	0.01	123	0.04	27	0.01	27	0.01
Tanytarsus spp.	20	0.01			24	< 0.01			13	< 0.01	23	0.01	3	< 0.01		
Ablabesmyia spp.	3	< 0.01							11	< 0.01	12	< 0.01				
other genera	22	0.01	5	0.02	14	< 0.01	4	0.03	16	< 0.01	51	0.01	1	< 0.01	7	< 0.01
Chaoborus spp.	17	0.01	15	0.07	49	0.01	14	0.10	27	< 0.01	90	0.03	7	< 0.01	9	< 0.01
C. punctipennis	16	0.01	12	0.06	41	0.01	11	0.08	15	< 0.01	67	0.02	4	< 0.01	5	< 0.01
C. flavicans	1	< 0.01	3	0.01	8	< 0.01	3	0.02	12	< 0.01	23	0.01	3	< 0.01	4	< 0.01
Oligochaeta	1486	0.48	66	0.32	2589	0.37	11	0.08	1338	0.24	160	0.05	1100	0.31	105	0.03
Other Taxa	65	0.02	7	0.03	153	0.02	16	0.11	84	0.02	84	0.02	43	0.01	8	< 0.01
Hydra spp.	20	0.01			42	0.01			2	< 0.01	2	< 0.01	1	< 0.01		
Mermithidae	5	< 0.01	2	0.01	4	< 0.01	1	0.01	7	< 0.01	12	< 0.01	3	< 0.01	1	< 0.01
Amphipoda	6	< 0.01	1	< 0.01	4	< 0.01	5	0.04	2	< 0.01	13	< 0.01				
Ephemeroptera							1	0.01	1	< 0.01	15	< 0.01			1	< 0.01
Zygoptera											1	< 0.01				
Trichoptera							1	0.01			2	< 0.01				
Haliplidae					3	< 0.01							1	< 0.01		
Ceratopogonidae	2	< 0.01	1	< 0.01	10	< 0.01	2	0.01	2	< 0.01	13	< 0.01	2	< 0.01	2	< 0.01
Hydracarina	3	< 0.01	3	0.01	11	< 0.01	6	0.04	11	< 0.01	19	0.01	2	< 0.01	1	< 0.01
Gastropoda	5	< 0.01			1	< 0.01			6	< 0.01	5	< 0.01	2	< 0.01		
Sphaeriidae	24	0.01			78	0.01			53	0.01	2	< 0.01	32	0.01	3	< 0.01
Total organisms	3088		208		6997		140		5466		3450		3545		3019	
Mean density per Ekman grab	77.2		5.2		87.5		3.2		124.2		17.4		147.7		53.9	
Number of taxa	16		10		15		12		16		18		14		11	
Index of diversity (H')	1.01		1.38		0.90		1.46		0.78		0.77		0.76		0.26	
Equitability (J)	0.37		0.60		0.33		0.59		0.28		0.27		0.29		0.11	

Table 2.3. (concl.)

South Baptiste

Taxon	1988				1989				1990				1991			
	15 m (n = 34)		25 m (n = 34)		15 m (n = 80)		25 m (n = 44)		15 m (n = 44)		25 m (n = 178)		15 m (n = 23)		25 m (n = 46)	
	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total	Total number collected	Proportion of total
Chironomus spp.	443	0.14	33	0.03	820	0.07	6	< 0.01	406	0.06	53	< 0.01	139	0.07	7	< 0.01
Other Chironomid Genera	155	0.05	54	0.06	121	0.01	11	< 0.01	20	< 0.01	38	< 0.01	36	0.02	68	0.04
Procladius spp.	151	0.05	54	0.06	111	0.01	8	< 0.01	18	< 0.01	35	< 0.01	32	0.02	66	0.04
Tanytarsus spp.					1	< 0.01										
other genera	4	< 0.01			9	< 0.01	3	< 0.01	2	< 0.01	3	< 0.01	4	< 0.01	2	< 0.01
Chaoborus spp.																
C. flavicans	935	0.30	845	0.90	6295	0.57	2607	0.99	4912	0.76	18740	0.99	369	0.19	1646	0.95
Oligochaeta	1527	0.50	2	< 0.01	3833	0.34	1	< 0.01	1138	0.18			1437	0.72		
Other Taxa	15	< 0.01	9	0.01	52	< 0.01	4	< 0.01	20	< 0.01	17	< 0.01	4	< 0.01	6	< 0.01
Hydra sp.					1	< 0.01										
Mermithidae	2	< 0.01			4	< 0.01			4	< 0.01	4	< 0.01				
Hirudinea					1	< 0.01							1	< 0.01		
Amphipoda	6	< 0.01	6	0.01	14	< 0.01	1	< 0.01	3	< 0.01	6	< 0.01	2	< 0.01	4	< 0.01
Ceratopogonidae	5	< 0.01	1	< 0.01	16	< 0.01	2	< 0.01	4	< 0.01	3	< 0.01			2	< 0.01
Hydracarina			1	< 0.01	6	< 0.01	1	< 0.01	6	< 0.01	4	< 0.01				
Gastropoda			1	< 0.01	2	< 0.01			1	< 0.01						
Sphaeriidae	2	< 0.01			8	< 0.01			2	< 0.01			1	< 0.01		
Total organisms	3075		943		11121		2629		6496		18848		1985		1727	
Mean density per Ekman grab	90.4		27.7		139.0		59.8		147.6		105.9		86.3		37.5	
Number of taxa	9		9		14		8		11		8		8		6	
Index of diversity (H')	1.18		0.45		0.97		0.06		0.73		0.04		0.83		0.22	
Equitability (J)	0.54		0.20		0.37		0.03		0.31		0.02		0.40		0.12	

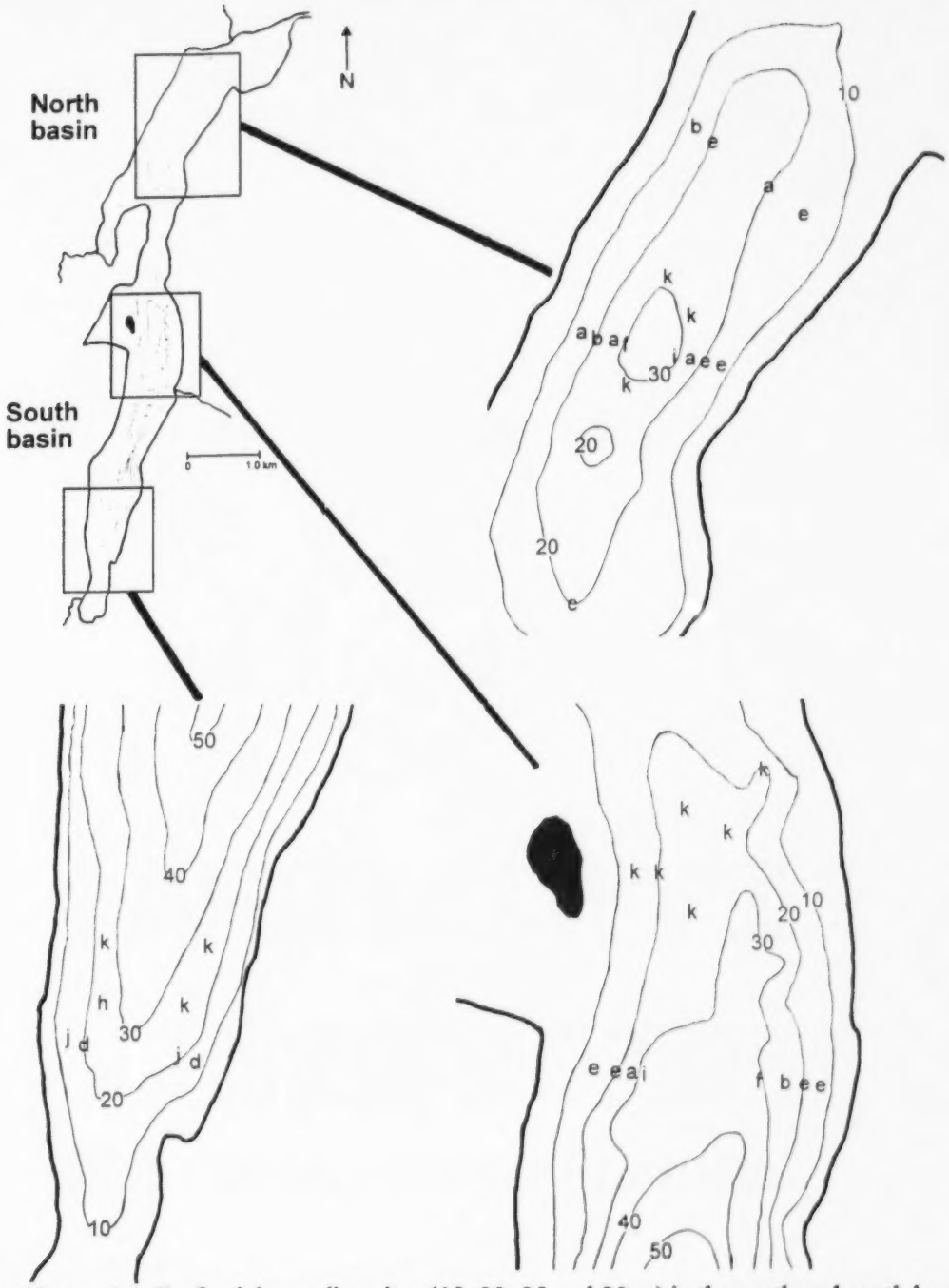

Figure 2.1. Profundal sampling sites (15, 20, 25 and 30 m) in the north and south basins of Amisk Lake, Alberta. Contours are in m. Letters mark the location and timing of samples as follows: **a** = 1988, 1989, 1990 and 1991; **b** = 1988, 1989 and 1990; **c** = 1988, 1990 and 1991; **d** = 1989, 1990 and 1991; **e** = 1988 and 1989; **f** = 1988 and 1991; **g** = 1989 and 1990; **h** = 1990 and 1991; **i** = 1988 only; **j** = 1989 only; **k** = 1990 only.

Figure 2.2. Profundal sampling sites (15, 20 and 25 m) in the south basin of Baptiste Lake, Alberta. Contours are in m. Letters mark the location and timing of samples as follows: **a** = 1988, 1989, 1990 and 1991; **b** = 1989, 1990 and 1991; **c** = 1988 and 1989; **d** = 1990 and 1991; **e** = 1989 only; **f** = 1990 only.

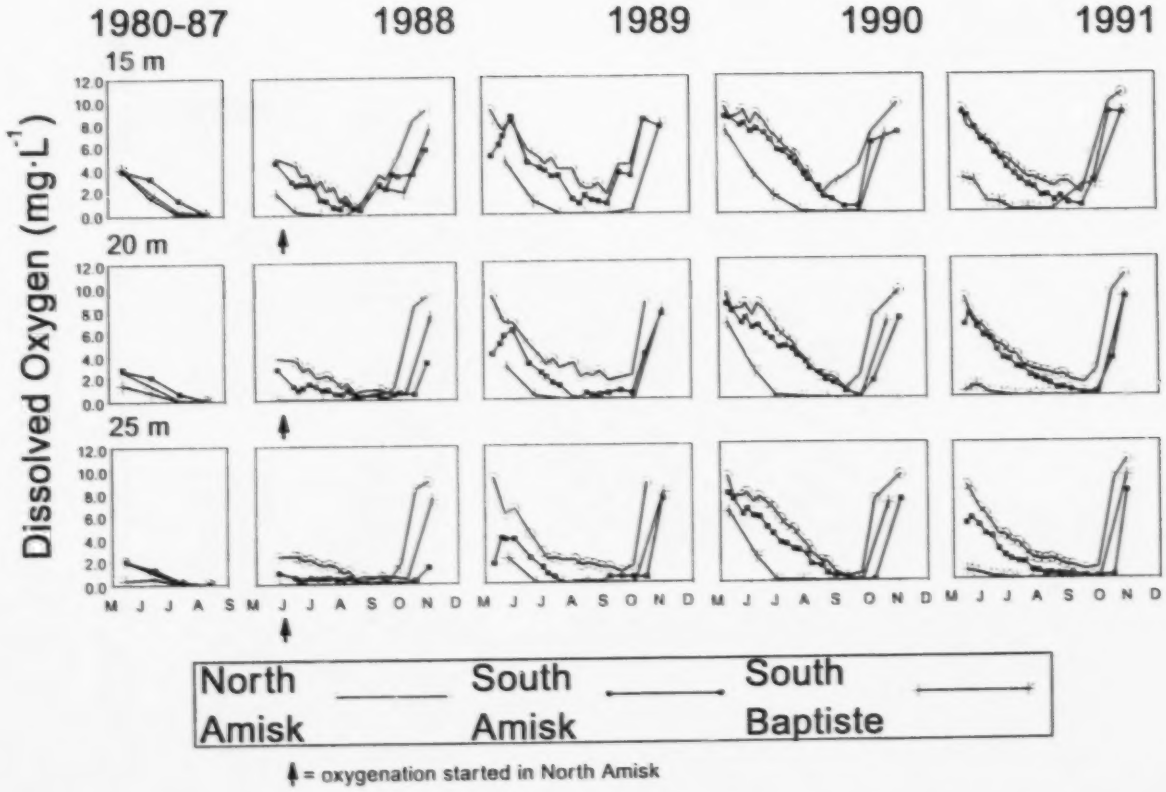

Figure 2.3. Hypolimnetic volume-weighted dissolved oxygen concentrations ($mg \cdot L^{-1}$) of 15-, 20- and 25-m strata, measured during the open-water season (May-November) for the north and south basins of Amisk Lake and the south basin of Baptiste Lake, 1980-1991. 1980-1987 represents the mean of 1980-1982 and 1987 (pre-treatment years).

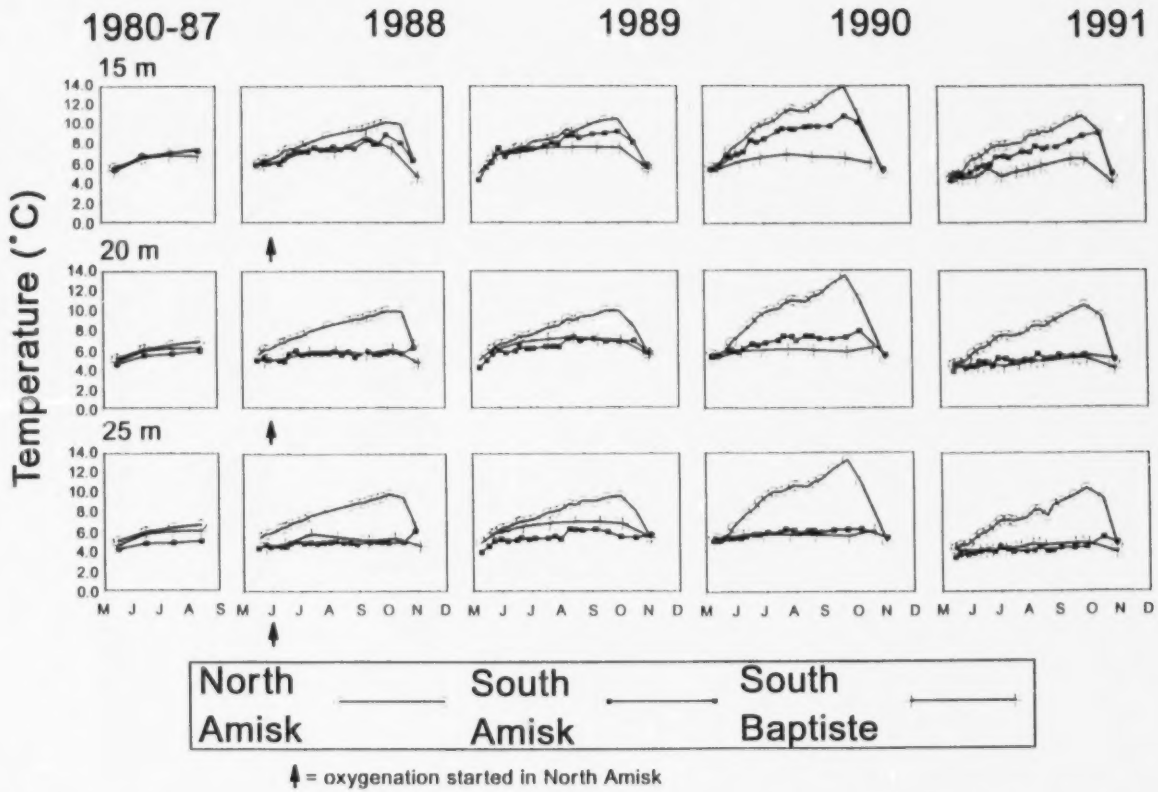

Figure 2.4. Hypolimnetic volume-weighted temperatures (°C) of 15-, 20- and 25-m strata, measured during the open-water season (May-November) for the north and south basins of Amisk Lake and the south basin of Baptiste Lake, 1980-1991. 1980-1987 represents the mean of 1980-1982 and 1987 (pre-treatment years).

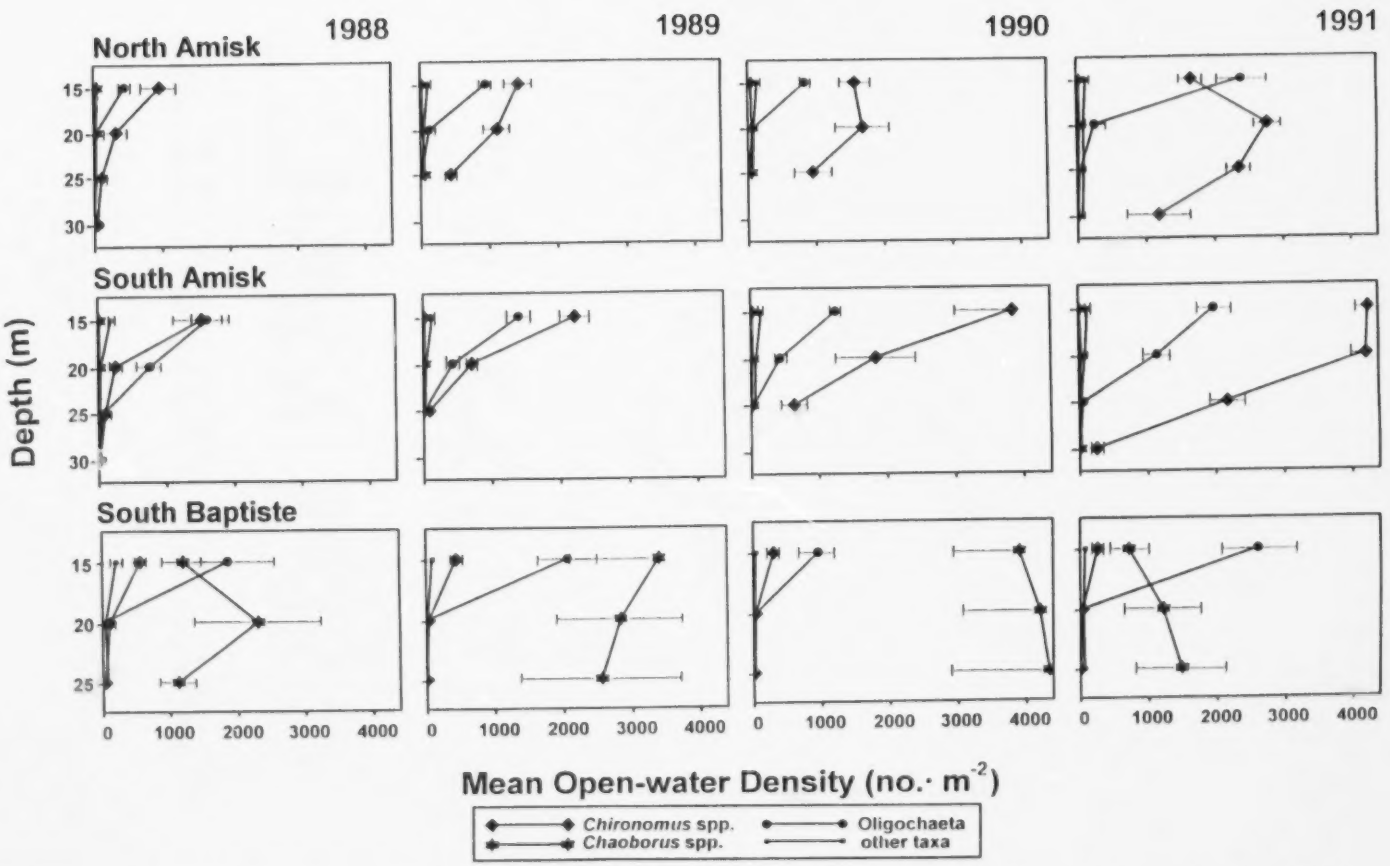

Figure 2.5. Mean open water densities (no.·m^{-2}) of major macroinvertebrate taxa collected at 15-, 20-, 25-, and 30-m (± 2.5 m) intervals in the north and south basins of Amisk Lake and the south basin of Baptiste Lake, 1988-1991. 30-m samples were not collected in Amisk Lake during 1989 and 1990. Maximum depth of South Baptiste was 27.5 m. Horizontal bars represent ± 1 SE.

2.5. References

Aku, P.M.K., L.G. Rudstam, and W.M. Tonn. In press. Impact of hypolimnetic oxygenation on the vertical distribution of cisco (Coregonus artedi) in Amisk Lake, Alberta. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Ashley, K.I. 1983. Hypolimnetic aeration of a naturally eutrophic lake: physical and chemical effects. Can. J. Fish. Aquat. Sci. 40: 1343-1359.

Ashley, K.I. 1985. Hypolimnial aeration: practical design and application. Water Res. 19: 735-740.

Aston, R.J. 1973. Tubificids and water quality: a review. Environ. Pollut. 5: 1-10.

Brinkhurst, R.O. 1974. The Benthos of Lakes. MacMillan Press, London. 190 p.

Brundin, L. 1951. The relation of oxygen-microstratification at the mud surface to the ecology of the profundal bottom fauna. Inst. Freshwater Res. Drottningholm 32: 32-42.

Carpenter, J.H. 1965. The Chesapeake Bay Institute technique for Winkler dissolved oxygen method. Limnol. Oceanogr. 10: 141-143.

Cornett, R.J., and F.H. Rigler. 1987. Decomposition of seston in the hypolimnion. Can. J. Fish. Aquat. Sci. 44: 146-151.

Cowell, B.C., C.J. Dawes, W.E. Gardiner, and S.E. Scheda. 1987. The influence of whole lake aeration on the limnology of a hypereutrophic lake in central Florida. Hydrobiologia 148: 3-24.

Davies, B.R. 1976. The dispersal of Chironomidae larvae: a review. J. Ent. Soc. Sth. Afr. 39: 39- 62.

Dinsmore, W.P., and E.E. Prepas. 1993. Changes in macroinvertebrate diversity in a deep eutrophic lake undergoing hypolimnetic oxygen injection, with particular reference to Chironomus spp. (Chironomidae). Verh. Internat. Verein. Limnol. 25: 302-306.

Dinsmore, W.P., and E.E. Prepas. In press. The impact of hypolimnetic oxygenation on profundal macroinvertebrates in a eutrophic lake in central Alberta. II. Changes in Chironomus spp. (Chironomidae) abundance and biomass. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Fast, A.W. 1971. The effects of artificial aeration on lake ecology. Ph.D. Thesis, Michigan State Univ., E. Lansing MI.

Field, K.M., and E.E. Prepas. In press. Increased depth distribution and abundance of pelagic zooplankton during hypolimnetic oxygenation of a eutrophic Alberta lake. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Heinis, F. 1993. Oxygen as a factor controlling occurrence and distribution of chironomid larvae. Ph.D. Thesis, Universiteit van Amsterdam, Amsterdam, The Netherlands.

Jónasson, P.M. 1978. Zoobenthos of lakes. Verh. Internat. Verein. Limnol. 20: 13-37.

Kajak, Z. 1987. Determinants of maximum biomass of benthic Chironomidae (Diptera). Ent. Scand. Suppl. 29: 303-308.

Lackey, R.T. 1973. Bottom fauna changes during artificial reservoir destratification. Water Res. 7: 1349-1353.

Lastein, E. 1976. Recent sedimentation and resuspension of organic matter in eutrophic Lake Esrom, Denmark. Oikos 27: 44-49.

Lawrence, G.A., J.M. Burke, T.P. Murphy, and E.E. Prepas. In press. Exchange flows between the two basins of Amisk Lake. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

McQueen, D.J., and D.R.S. Lean. 1986. Hypolimnetic aeration: an overview. Water Poll. Res. J. Can. 21: 205-217.

Nagell, B., and C.C. Landahl. 1978. Resistance to anoxia of Chironomus plumosus and Chironomus anthracinus (Diptera) larvae. Holarct. Ecol. 1: 333-336.

Pastorok, R.A., T.C. Ginn, and M.W. Lorenzen. 1980. Review of aeration/circulation for lake management. p. 124-133. In Restoration of Lakes and Inland Waters. EPA 440/5-81-010. U.S. Envir. Prot. Ag., Washington D.C.: 562 p.

Prepas, E.E. 1990a. Amisk Lake. p. 225-231 In P. Mitchell and E.E. Prepas [ed.] Atlas of Alberta Lakes. University of Alberta Press, Edmonton, AB. 675 p.

Prepas, E.E. 1990b. Baptiste Lake. p. 122-130 In P. Mitchell and E.E. Prepas [ed.] Atlas of Alberta Lakes. University of Alberta Press, Edmonton, AB. 675 p.

Prepas, E.E., and J.M. Burke. In press. Hypolimnetic oxygen injection as a method of improving water quality in lakes with large internal inputs of phosphorus. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Reynoldson, T.B. 1987. The role of environmental factors in the ecology of tubificid oligochaetes- an experimental study. Holarct. Ecol. 10: 241-248.

Saether, O.A. 1979. Chironomid communities as water quality indicators. Holarct. Ecol. 2: 65-74.

Shannon, C.E., and W. Weaver. 1949. The mathematical theory of communication. University of Illinois Press, Urbana.

Sikorowa, A. 1978. Changes of the distribution and number of the bottom fauna as an effect of artificial lake aeration. Verh. Internat. Verein. Limnol. 20: 1000-1003.

Takamura, K., and T. Iwakuma. 1990. Fate of macrobenthos in hypereutrophic lakes: in situ rearing experiments with the larvae of Tokunagayusurika akamusi (Chironomidae). Arch. Hydrobiol. 119: 65-78.

Webb, D.J., R.D. Robarts, and E.E. Prepas. In press. Influence of extended water column mixing during the first two years of hypolimnetic oxygenation on the phytoplankton community of Amisk Lake, Alberta. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Wilhm, J., and N. McClintock. 1978. Dissolved oxygen concentration and diversity of benthic macroinvertebrates in an artificially destratified lake. Hydrobiologia 57: 163-166.

3. Impact of hypolimnetic oxygenation on profundal macroinvertebrates in a eutrophic lake in central Alberta. II. Changes in Chironomus spp. abundance and biomass.[1]

3.1. Introduction

Larvae of Chironomidae (Diptera) are typically the most abundant and diverse group of insects found in lentic environments (Oliver 1971; Pinder 1986). Dissolved oxygen (DO) concentration is often a primary factor determining profundal chironomid distribution and abundance in water bodies of moderate to high primary productivity (Brundin 1951; Thienemann 1954; Saether 1979). Profundal macroinvertebrate communities in eutrophic northern temperate lakes and reservoirs are low in diversity and Chironomus spp., a detritivore tolerant of low oxygen conditions, is often dominant (Jónasson 1978; Saether 1979). Under ideal conditions, Chironomus larvae can attain densities of several thousand·m^{-2} (Hilsenhoff 1966; Kajak 1987), converting large deposits of organic detritus into a food source for fish. However, Chironomus is rare or absent from depths where anoxic conditions (DO concentrations < 1.0 mg·L^{-1}) persist (Heinis 1993).

Chironomus spp. tolerance to low-DO conditions appears to vary among species. For example, C. anthracinus distribution is limited by DO concentrations < 1-3 mg·L^{-1} (Dermott et al. 1977; Jónasson 1978; Heinis and Crommentuijn 1992). In comparison, C. plumosus can survive at least twice as long as C. anthracinus under anoxic conditions (Nagell and Landahl 1978; Bairlein 1989). Chironomus spp. also prefer different water temperatures. For example, C. plumosus prefers warm hypolimnetic temperatures typical of shallow lakes (Hilsenhoff 1966), whereas C. anthracinus prefers the cool waters of deep lakes (Jónasson 1978). This suggests that a combination of DO concentrations and temperatures determines distributions of individual species of Chironomus spp. within

[1] This chapter is currently in press. W.P. Dinsmore and E.E. Prepas. 1996. Can. J. Fish. Aquat. Sci. vol. 53.

lakes.

Hypolimnetic aeration has often been used to increase hypolimnetic DO concentrations in lakes and reservoirs (see reviews by Pastorok et al. 1980; McQueen and Lean 1986). Little is known about Chironomus spp. response to hypolimnetic aeration. Previous aeration studies (e.g., Fast 1971; Sikorowa 1978; Pastorok et al. 1980; Cowell et al. 1987) described chironomid responses at the family level over the short term (1-3 yr), in small (mean surface area < 14 ha), relatively shallow (mean Z_{max} < 15 m) lakes. Injection of pure oxygen into the hypolimnion of Amisk Lake, a eutrophic lake located in central Alberta, was intitiated in June 1988 (Prepas and Burke, In press). In contrast to past aeration projects, treatment was conducted over 4 yr on a relatively large (surface area = 515 ha, Z_{max} = 60 m; Prepas 1990b) double-basined lake.

This study addresses the effects of hypolimnetic oxygenation on the abundance and biomass of species of Chironomus in the profundal region. Responses of Chironomus spp. in Amisk Lake were compared to those in Baptiste Lake, a nearby reference system. I hypothesized that Chironomus spp. response to hypolimnetic oxygenation in Amisk Lake would be influenced by a combination of increased hypolimnetic DO and temperatures, but that individual species would respond differently.

3.2. Methods

The collection and analysis of hypolimnetic volume-weighted DO and temperature data and the sampling protocol for Chironomus spp. are outlined in Dinsmore and Prepas (In press). Populations of profundal Chironomus spp. were sampled using an Ekman grab from May to November 1988 to 1991 in the treated north (North Amisk) and reference south (South Amisk) basins of Amisk Lake and in the reference south basin of nearby Baptiste Lake (South Baptiste), which was morphometrically similar but more productive than the oxygenated basin (Fig. 3.1). A mesh size of 500 µm was used for all sieves. Samples were collected at stations established at 15, 20 and 25 m (± 2.5 m), which represented the upper, middle and deep profundal regions of each basin. A maximum

sampling depth of 25 ± 2.5 m was selected based on the maximum depth of South Baptiste, the shallowest of the three basins used in this study (Z_{max} = 27.5 m; Prepas 1990a). Pre-treatment hypolimnetic DO concentrations and temperatures were averaged from 1980 to 1982 and 1987 data, whereas each treatment year (1988 to 1991) was considered separately. Hypolimnetic volume-weighted DO concentrations and temperatures for each basin were calculated for 15-, 20- and 25-m (± 3 m) strata, corresponding to the sampling intervals chosen for profundal macroinvertebrate sampling. This paper will concentrate primarily on 25 m to (1) illustrate trends in hypolimnetic DO and temperatures that occurred in the three basins at similar depths, and (2) examine the most extreme changes in physical and biological conditions.

Chironomus anthracinus Zetterstedt and species of the C. plumosus (Linnaeus) group were identified by chromosomal analysis of fourth-instar larvae (P. Michailova, Bulgarian Academy of Sciences, Sofia, personal communication), and C. cucini Webb and C. decorus (Johannsen) were identified from reared adult males (D.R. Oliver and M.E. Dillon, Agriculture Canada, Ottawa, personal communication). Once species names were established, Chironomus larvae were identified under a dissecting microscope according to morphological differences in abdominal tubuli (Appendix F). Chironomus plumosus group was composed of four species: C. balatonicus Devai, Wülker, Scholl (South Baptiste), C. entis Schobanov (South Amisk), C. muratensis Ryser, Scholl, Wülker (Amisk Lake) and C. staegeri (Lundbeck) (South Baptiste). Larvae of these species could not be separated visually. All C. cucini larvae collected from South Baptiste possessed tubuli, whereas tubuli were absent in > 99% of larvae taken from Amisk Lake (Appendix B). Chironomus decorus is a highly variable species group in North America, containing as many as 15 cytologically distinct species (Martin 1979).

Increased hypolimnetic DO concentrations in South Amisk in 1990 indicated that oxygen was being transferred from North to South Amisk (Lawrence et al., In press). Benthic samples taken from the northern ("near end") and southern ("far end") areas of South Amisk (Fig. 3.1) were examined to detect possible effects of this oxygen transfer on Chironomus densities. Mean densities (no.·m^{-2}) were estimated for each Chironomus taxon

from May to early November of each treatment year. Densities for each depth interval among basins and between the near and far ends of South Amisk were compared with paired t-tests. P was set at 0.01 to avoid type I errors as a result of multiple comparisons; n, the number of paired sampling dates, ranged from 9 to 13 per year from 1988 to 1991. Paired comparisons of means remove all differences between samples except those resulting from treatment (Sokal and Rohlf 1981). However, null hypotheses (e.g. H_0: no dectectable differences in Chironomus spp. abundances exist between North and South Amisk) will not be rejected if differences between paired samples are not consistent, even though the two means ± SE under comparison may not overlap.

Mean larval weights (mg unpreserved dry weight) and total biomasses ($mg \cdot m^{-2}$) were estimated for each Chironomus taxon in the deep profundal regions (25 m) of the three study basins from 1988 to 1991. These estimates were derived from two sampling stations each in North Amisk and South Baptiste. In South Amisk, the data were collected from two near-end stations in 1988 and 1989, two stations each at the near and far ends in 1990, and one station each at the near and far ends in 1991 (Fig. 3.1). Mean larval weight and total weight for each Chironomus taxon present per grab were determined to the nearest 0.1 mg of preserved wet weight with a Mettler AT261 DeltaRange balance. Preserved wet weights were converted to unpreserved dry weights with a calculated conversion value of 0.136 (WPD, unpublished data). Biomasses of combined Chironomus spp., individual species and individual larvae were compared as described for densities; however, when mean larval weights of a particular taxon were compared between basins, n equalled the number of sampling dates when individuals were present in both basins under consideration. Mean open-water biomass ± SE for each Chironomus taxon was determined for among-basin comparisons.

3.3. Results

Hypolimnetic Dissolved Oxygen and Temperature

Trends in hypolimnetic volume-weighted DO and temperature in Amisk and Baptiste lakes before and after hypolimnetic oxygenation are described in Prepas and

Burke (In press) and Dinsmore and Prepas (In press). During pre-treatment years, the deep hypolimnion (25 m) was anoxic from early June/early July until fall turnover in North and South Amisk (3-4 mo) and from mid-May until fall turnover in South Baptiste (5 mo). After hypolimnetic oxygenation commenced in June 1988, the anoxic period in North Amisk was shortened to 3-6 wk from 1988 to 1991. The increase in hypolimnetic DO concentrations in South Amisk as a result of transfer of oxygenated water from North Amisk was not detected until 1990 and 1991. Although DO concentrations at 25 m during treatment remained lower in South Amisk (mean August DO concentrations: 0.4 ± 0.1 $mg \cdot L^{-1}$) than in North Amisk (1.4 ± 0.1 $mg \cdot L^{-1}$), the anoxic period in South Amisk during 1990 and 1991 was reduced to 2-3 mo from 3-4 mo. In comparison, the hypolimnion of South Baptiste at 25 m still remained anoxic for 5 mo.

Enhanced hypolimnetic mixing as a result of oxygenation in North Amisk increased hypolimnetic temperatures at 25 m relative to previous years, although thermal stratification still persisted. Mean August temperature in North Amisk increased from 6.7 ± 0.2 C (pre-treatment) to 9.1 ± 0.6 C (1988-1991), with a maximum of 10.8 ± 0.2 C in 1990. The transfer of warm water from North Amisk did not appear to influence water temperatures in the hypolimnion of South Amisk. The annual variation in hypolimnetic temperatures at 25 m was similar in South Amisk and South Baptiste: mean August temperatures increased from 5.0 ± 0.2 and 6.1 ± 0.3 C before 1989 to 6.2 ± 0.03 and 7.0 ± 0.1 C in 1989, and then declined to 4.2 and 4.7 C (± 0.1 C) in 1991. North Amisk temperatures increased after oxygenation, but annual variation caused by regional weather patterns existed, as indicated by similar temperature patterns among North Amisk, South Amisk and South Baptiste.

Chironomus spp. Abundance

Chironomus spp. densities in Amisk Lake increased greatly over the study period relative to other profundal macroinvertebrate taxa (Dinsmore and Prepas, In press). Chironomus anthracinus was the most abundant species in both basins of Amisk Lake from 1988 to 1991. Densities in both basins increased after hypolimnetic oxygenation

began, although major changes only became apparent in the latter half of 1990 (Fig. 3.2). Densities of C. anthracinus in 1988 were low in both basins and were similar between basins at all sampling intervals ($P > 0.45$). In 1989, densities of C. anthracinus were significantly higher at 25 m in North Amisk ($P < 0.01$) but were lower than in South Amisk at 15 m ($P < 0.001$); densities did not differ between basins at 20 m ($P > 0.19$). In 1990, C. anthracinus densities at all depths from early May to mid-July were comparable to those in early 1988, increased in early August, and peaked in late fall in both basins. There were no detectable differences in 1990 densities between North and South Amisk at all sampling depths ($P > 0.16$), although peak fall densities were usually higher in South Amisk than in North Amisk. Maximum densities of C. anthracinus for the study period were recorded in 1991; those at 15 and 20 m were significantly higher in South Amisk than in North Amisk ($P < 0.001$), whereas densities at 25 m were similar between the two basins ($P < 0.05$). Spatial differences in C. anthracinus densities within South Amisk were not significant throughout the study.

Densities of C. cucini, the second-most abundant species in Amisk Lake, increased in both basins as hypolimnetic oxygenation progressed, but to a greater degree in South Amisk (Fig. 3.3). In 1988, densities of C. cucini were significantly higher in South Amisk relative to North Amisk at all sampling depths ($P < 0.01$). Numbers of C. cucini increased in South Amisk at 15 and 20 m during 1989 but remained low in North Amisk; densities at 25 m were similar between basins ($P > 0.54$). In 1990, North Amisk densities increased slightly at 20 and 25 m but densities remained low at 15 m; however, South Amisk densities increased dramatically at 20 and 25 m. Maximum densities of C. cucini were noted in 1991 at all sampling depths in both basins; densities at 25 m were much higher in South Amisk relative to North Amisk ($P < 0.001$). No differences were noted between the near and far ends of South Amisk until 1991, when densities at the far end (20 m: 1582 ± 200; 25 m: $1569 \pm 180 \cdot m^{-2}$) were significantly higher ($P < 0.001$) than at the near end (20 m: 241 ± 31; 25 m: $110 \pm 62 \cdot m^{-2}$). Near-end densities in South Amisk were similar to whole-basin densities in North Amisk at 20 m in 1991 ($P > 0.05$) and 25 m in 1990 ($P > 0.07$) and 1991 ($P > 0.06$).

Densities of C. decorus in North Amisk declined from early May to late September, but often increased in the fall (Fig. 3.4), a pattern unique among the profundal Chironomus species of Amisk and Baptiste lakes. The pattern appeared to coincide with the summer decrease and fall increase in hypolimnetic DO concentrations. Minimum densities observed during the study period at 20 and 25 m in North Amisk occurred when hypolimnetic DO concentrations were < 2 $mg \cdot L^{-1}$ at these depths (Dinsmore and Prepas, In press). However, the same pattern was not evident in South Amisk, probably because densities were low (< $100 \cdot m^{-2}$ at all sampling depths) throughout the study. Densities at 15 and 20 m in North Amisk fluctuated from year to year but densities at 25 m increased steadily over the study period; by 1991, densities at 25 m had surpassed those at 15 m. During 1988, densities of C. decorus in North and South Amisk were similar at all depths ($P > 0.07$, 0.03 and 0.27 at 15, 20 and 25 m, respectively). In later years, densities were consistently higher in North Amisk than in South Amisk for all sampling depths, except at 15 m during 1990 ($P > 0.23$). In 1991, C. decorus was absent from South Amisk at 15 m, and densities at 20 and 25 m in this basin were low. Near-end densities were higher than far-end densities only at 25 m in 1991 ($P < 0.01$).

The C. plumosus group was the least abundant of the Chironomus spp. present in Amisk Lake. Numbers increased during the study period at all sampling depths in North Amisk but not in South Amisk (Fig. 3.5). Highest densities during the study occurred at 20 m in North Amisk in 1991 (September and October: > $400 \cdot m^{-2}$), compared to 0-$10 \cdot m^{-2}$ in South Amisk. During 1988, C. plumosus group densities in North and South Amisk were similar ($P > 0.12$ and 0.61 at 15 and 20 m, respectively; C. plumosus group larvae were absent at 25 m in South Amisk), but densities were significantly higher in North Amisk in subsequent years ($P < 0.001$ at 15 and 20 m; $P < 0.01$ at 25 m). Densities within South Amisk did not appear to be related to location.

Chironomus spp. larval recruitment appeared to increase in both basins of Amisk Lake as treatment progressed. Densities of both pupae and early instar larvae at 15 m were higher in 1990 than in 1988 in both basins (Fig. 3.6). Pupal densities were higher in North Amisk than in South Amisk at 15 m during 1988 and 1990, but densities of early instar

larvae were higher in South Amisk during the same period. Densities of Chironomus spp. pupae and early instar larvae were also higher at 20 and 25 m in 1990 than in 1988; densities of early instar larvae in North and South Amisk were similar in 1990 at these two depths. Large numbers of pupae were collected during 1991, but few early instar larvae were collected afterwards.

In South Baptiste, already low Chironomus spp. densities declined further over the study period (Fig. 3.7). Chironomus cucini and C. plumosus group dominated the profundal region; C. anthracinus was present only at 15 m and only one specimen of C. decorus was collected during the entire study period. During 1988, densities of C. cucini were higher in South Baptiste at 15 m than in North Amisk ($P < 0.01$), but were similar to North Amisk at 20 and 25 m ($P > 0.50$ and 0.07, respectively). Densities in subsequent years became similar between the two basins at 15 m ($P > 0.58$) and higher in North Amisk at 20 and 25 m ($P < 0.01$ and 0.001, respectively). Similarly, densities of C. plumosus group larvae were higher in South Baptiste than in North Amisk at all depths during 1988 ($P < 0.01$), but in 1991 were similar at 15 m ($P > 0.54$) and higher in North Amisk at 20 and 25 m ($P < 0.001$). Densities of C. anthracinus in South Baptiste were always low; none were collected in 1990. Differences in C. anthracinus densities between North Amisk and South Baptiste at 15 m were not distinguishable during 1988 ($P > 0.14$), but densities were higher in North Amisk during 1989 and 1991 ($P < 0.001$). The collection of Chironomus spp. early instar larvae and pupae was sporadic in South Baptiste.

Chironomus spp. Biomass and Larval Weights

Total Chironomus spp. biomass at 25 m increased in both basins of Amisk Lake from 1988 to 1991 (Table 3.1). The degree to which mean larval weights of Chironomus spp. changed in Amisk Lake varied with species and basin (Table 3.2). Differences in biomass between North and South Amisk and between North Amisk and South Baptiste (Table 3.1) were not detectable during 1988 ($P > 0.33$), but were significant in subsequent years ($P < 0.01$). Peak total Chironomus spp. biomass was observed during 1991 in both

basins of Amisk Lake, whereas biomass in South Baptiste remained low throughout the study. Although whole-basin Chironomus spp. density estimates at 25 m were similar between the two basins of Amisk Lake during 1991 (Figs. 2.5, 3.2), biomass estimates for the same year were significantly higher in North Amisk ($P < 0.001$). However, biomass at the far end of South Amisk was significantly higher than at the near end during 1991 ($P < 0.01$) and was similar to whole-basin estimates for North Amisk ($P > 0.07$). Larval weights did not differ significantly with respect to location within South Amisk for any Chironomus taxon ($P > 0.09$).

Chironomus anthracinus contributed most of the Chironomus spp. biomass in North Amisk, whereas both C. anthracinus and C. cucini were important in South Amisk (Table 3.1). During 1988, C. anthracinus mean biomass was low in North Amisk (larvae were present on only three of nine sampling dates) but increased gradually in 1989 and 1990. By 1991, maximum biomass for the study period was reached in North Amisk. Biomass estimates for C. anthracinus in South Amisk increased in a similar manner. No differences in C. anthracinus biomass at 25 m were detected between North and South Amisk in 1988 ($P > 0.40$) and 1990 ($P > 0.08$), but differences were present during 1989 and 1991 ($P < 0.01$). Mean larval weights of C. anthracinus in North and South Amisk were similar during 1988 but the differences between the two basins were highly significant in subsequent years (Tables 3.2, 3.3). Although densities of C. anthracinus responded similarly to hypolimnetic oxygenation in North and South Amisk during 1991 (Fig. 3.2), larval weights and biomass were greater in North Amisk (Tables 3.2, 3.3).

Biomass of C. cucini also increased progressively in both basins of Amisk Lake, but tended to be higher in South Amisk (Table 3.1). Differences between basins were significant in 1988 ($P < 0.01$) but not in 1989 and 1990 ($P > 0.52$). Like C. anthracinus, C. cucini biomass increased dramatically in both basins of Amisk Lake during 1991, but biomass in South Amisk was significantly higher ($P < 0.001$) than in North Amisk. Also, biomass was greater ($P < 0.001$) at the far end of South Amisk than at the near end in 1991. Larval weights of C. cucini were significantly higher in North Amisk than in South Amisk during 1991 (Tables 3.2, 3.3). Although C. cucini were on average larger bodied in

North Amisk, biomass of C. cucini was higher in South Amisk because of the higher densities in that basin (Fig. 3.3).

Biomass of C. decorus was low in both North and South Amisk during 1988 but increased in North Amisk in subsequent years, becoming highest in 1991 (Table 3.1). In contrast, biomass in South Amisk remained < 50 $mg \cdot m^{-2}$ for the duration of the study. Differences in C. decorus biomass between basins were nonsignificant from 1988 to 1990 ($P > 0.64$, 0.07 and 0.02 for 1988, 1989 and 1990, respectively), but differences were significant during 1991 ($P < 0.01$). Mean larval weights of C. decorus remained similar in North and South Amisk over the study period (Tables 3.2, 3.3). Larval weights were relatively constant from 1988 to 1990 but decreased slightly in both basins during 1991.

Biomass of C. plumosus group was low in both basins in 1988, but progressively increased in North Amisk over the study period (Table 3.1). Biomass remained low or non-existent in South Amisk. Biomass was similar in North and South Amisk in 1988 ($P > 0.71$) but was significantly higher in North Amisk from 1989 to 1991 ($P < 0.01$). Chironomus plumosus group larvae were the largest of the Chironomus taxa present in Amisk Lake (Table 3.2). Differences in C. plumosus group larval weights between North and South Amisk were not tested statistically because of the limited number of concurrent collections. However, mean C. plumosus group larval weights were consistently larger in North Amisk than in South Amisk over the course of the study (Table 3.2).

Early instar Chironomus spp. larvae were not collected at 25 m from either basin of Amisk Lake during 1989 and 1991, and contributed only a small proportion of the total biomass during 1988 and 1990 (Table 3.1). However, biomass estimates were higher in North Amisk than in South Amisk during 1988 and 1990. Chironomus spp. pupal biomasses increased in both basins of Amisk Lake during treatment, but were higher in North Amisk than in South Amisk because of higher densities of pupae collected during 1990 and 1991 (Fig. 3.6). Individual weights of early larval instars and pupae were not compared statistically, but appeared to be higher in North Amisk than in South Amisk (Table 3.2).

Only C. cucini and C. plumosus group were present at 25 m in South Baptiste (Table 3.1). Chironomus plumosus group contributed 79-100% of the biomass. Biomass of both taxa at 25 m generally decreased in South Baptiste over the study period, in contrast to the patterns observed in both basins of Amisk Lake. There were no significant differences in C. cucini biomass between North Amisk and South Baptiste during 1988 ($P > 0.26$), but biomass was higher in North Amisk in subsequent years ($P < 0.01$). In contrast, C. plumosus group biomass was higher in South Baptiste than in North Amisk during 1988 ($P < 0.01$) but biomasses were similar during subsequent years ($P > 0.02$, 0.31 and 0.51 for 1989, 1990 and 1991, respectively). Mean larval weights of C. cucini and C. plumosus group collected in South Baptiste were generally higher than those in Amisk Lake (Table 3.2), although South Baptiste produced fewer individuals per sample (Fig. 3.7 cf. Figs. 3.3, 3.5). Only four comparisons of larval weights between Amisk and Baptiste lakes were possible (Table 3.3). Of these, only 1990 C. cucini were significantly smaller in North Amisk than South Baptiste (Table 3.2; $P=0.01$).

3.4. Discussion

The results of this study suggest that more Chironomus species than previously thought may coexist in the profundal communities of North American lakes. Previous studies of northern temperate lakes similar in productivity to Amisk and Baptiste lakes reported the presence of only one or two species (e.g. Jónasson 1978; Butler and McMillan 1990). The detection of at least four species of Chironomus in the profundal regions of Amisk and Baptiste lakes is paralleled only by Butler et al. (In press). Also, C. balatonicus and C. muratensis have not been reported from Nearctic lakes (Oliver et al. 1990; Butler et al., In press).

Chironomus anthracinus densities increased 55-fold and biomasses increased 109-fold at 25 m in North Amisk from 1988 to 1991. This increase coincided with a reduction in the duration of open-water anoxic conditions at this depth from ~ 4 mo during pre-treatment years to 3-6 wk, and the elimination of winter anoxia (Prepas and Burke, In

press). A mean temperature increase of 2.5 C in the hypolimnion of North Amisk during treatment did not limit C. anthracinus colonization of the profundal region and may have improved larval metabolic and feeding rates. A similar increase in C. anthracinus densities in untreated South Amisk occurred with a decline in hypolimnetic temperatures during 1991, suggesting that hypolimnetic temperatures were not the primary factor limiting C. anthracinus expansion into the deep profundal regions of Amisk Lake. The transfer of oxygenated water from North to South Amisk during 1990 and 1991 also resulted in a reduction of anoxic conditions in South Amisk, although the anoxic period (2-3 mo during 1990-1991) was still long relative to North Amisk (1 mo). Although C. anthracinus were more numerous in South Amisk relative to North Amisk at all depths except 25 m by 1991, mean biomass at 25 m in North Amisk was almost three times that of South Amisk during the same year. Larval weights of C. anthracinus were at least 1.5 times larger in North Amisk from 1989 onwards. This suggests that the reduction in anoxic conditions in North Amisk enabled C. anthracinus to continue feeding and growing longer during the open-water season than was possible in South Amisk.

A major response in C. anthracinus densities and biomass in North Amisk was not apparent until the latter half of 1990, 2 yr after hypolimnetic oxygenation commenced. Fast (1971) also noted a lag of 1 yr between the beginning of treatment and chironomid response in Section Four and Hemlock lakes, Michigan. Life-history analyses were not done for C. anthracinus in Amisk Lake, but profundal populations in other northern temperate lakes commonly have lifespans of $\geq$ 2 yr (Jónasson 1978; Pinder 1986), which are determined in part by low hypolimnetic temperatures. Hypolimnetic oxygenation in North Amisk may have improved larval recruitment of C. anthracinus in 1990 rather than encouraged colonization of deeper depths by the 1988-1989 cohort, although it may have improved survivorship of larvae already present at 20 and 25 m during 1988 and 1989. It is unknown whether the increase in C. anthracinus in South Amisk was a result of increased survivorship of resident larvae and reproductive success of the resulting adults, or to the dispersal of larvae and adults from North Amisk.

Densities of C. plumosus group in North Amisk increased relative to South Amisk during the study but remained of minor importance compared to C. anthracinus and C. cucini. Although C. plumosus is highly tolerant of anoxic conditions (Nagell and Landahl 1978; Bairlein 1989), larvae were never abundant in the profundal regions of any of the three basins. The hypolimnia of Amisk and Baptiste lakes were probably too cool to allow substantial colonization by this taxon, although the slight increase in hypolimnetic temperatures in North Amisk may have partly accounted for the increase in densities there relative to South Amisk and South Baptiste. Also, since C. plumosus is primarily a filter-feeder (Johnson 1987), species of this group may be more likely to occupy shallow depths or lakes with large fetches where currents can readily supply suspended food material. However, possible interpretations are limited because C. plumosus group in the lakes of this study was a collection of species, each with potentially different habitat requirements.

Little is known of the biology of C. cucini and C. decorus or their responses to gradients in DO concentrations and temperature. The presence of C. cucini in the deep, low-DO habitats of South Amisk and South Baptiste conflicts with Butler et al. (In press). These authors suggest that this species is an indicator of oligo-mesotrophic lakes that have oxygen regimes adequate for coregonid and salmonid fishes. Increased C. cucini larval weights in North Amisk relative to South Amisk suggest that this species benefited from improved DO conditions, like C. anthracinus. It is unknown why densities and biomasses of C. cucini were highest at the southernmost end of South Amisk, which was farthest away from the transfer of oxygenated water from North Amisk.

The seasonal decline and resurgence in C. decorus abundance in North Amisk mirrored changes in open-water DO concentrations. No pupae were collected during the periods of decline, suggesting that C. decorus larvae may have migrated to shallower depths to avoid anoxic conditions. Dispersal through the water column has been noted in third- and fourth-instar Chironomus spp. larvae (Davies 1976); the reasons for this behaviour are poorly understood but the stimulus may be decreasing DO concentrations (Bay et al. 1966; Heinis 1993). Larval weights of C. decorus remained similar in North and South Amisk throughout the study; few C. decorus larvae were present at the depths

sampled when increased hypolimnetic DO concentrations were most beneficial. However, since C. decorus is considered to be a group of morphologically similar species (Martin 1979), the response of larvae from Amisk Lake may differ from decorus-type larvae in other lakes.

The impact of fish predation was not quantified but may explain why Chironomus spp. densities at 15 m in North Amisk were depressed relative to similar depths in South Amisk. During August of 1990, 70-80% of fish in South Amisk were restricted to depths shallower than 7 m by a combination of low DO concentrations and low water temperatures, whereas > 60% of fish in North Amisk were distributed between 9-15 m (Aku et al., In press). This suggests that a significant difference in maximum benthic foraging depth existed between the treated and untreated basins of Amisk Lake. Yellow perch (Perca flavescens) were the main benthivorous fish in Amisk Lake, but their distribution was not studied in detail. Cisco (Coregonus artedi), though mainly zooplanktivorous, also foraged for chironomids (P.M.K. Aku, University of Alberta, Edmonton, unpublished data). Cisco in Amisk Lake selected DO concentrations of 1.7-4.3 $mg \cdot L^{-1}$ within a preferred temperature range of 9.7-13.9 C, a combination that existed at 7-13 m in North Amisk in 1989 and 1990 (Aku et al., In press). Cisco and yellow perch had potential access to large numbers of C. anthracinus present in the upper profundal zone of North Amisk from 1990 onwards. In contrast, lower DO concentrations in South Amisk suggest that predation pressure on Chironomus spp. at comparable depths was light. Low DO concentrations made foraging bioenergetically costly for fish at depths > 13 m in North Amisk and > 7 m in South Amisk for most of the open-water season (Aku et al., In press), so fish predation on Chironomus spp. in the deep profundal regions (> 15 m) of both basins was considered negligible.

Increased Chironomus spp. densities in Amisk Lake may have implications beyond an enlarged forage base for fish. Tube-building by high densities of Chironomus spp. can retard the resuspension of profundal sediments during turnover events (Jónasson 1978), reducing an important source of nutrients for epilimnetic phytoplankton. Chironomus spp. enhancement through hypolimnetic oxygenation could lead to a significant increase in

hypolimnetic DO demand through respiration that did not exist prior to treatment (Takada and Kato 1991). Bioturbation by larvae may increase sediment oxygen demand and oxygen depletion rates in the water column (Fukuhara and Sakamoto 1987; Tatrai 1988; Frenzel 1990). Chironomus anthracinus burrows in Lake Maarsseveen I consumed three times as much DO as the larvae occupying them (Heinis et al. 1989). Also, increased chironomid bioturbation may promote sediment/water exchange of other compounds such as silica, ferric iron, ammonium, and phosphate (Fukuhara and Sakamoto 1987; Tatrai 1988; Frenzel 1990). In Lake Balaton, total phosphorus (TP) release rates were as high as 17 $mg \cdot m^{-2} \cdot d^{-1}$ for Chironomus spp. densities of 20 $000 \cdot m^{-2}$ (Tatrai 1988). However, hypolimnetic TP release rates in Amisk Lake declined from pre-treatment values of 7.8 (North Amisk) and 11.0 $mg \cdot m^{-2} \cdot d^{-1}$ (South Amisk) to 3.4 and 7.9 $mg \cdot m^{-2} \cdot d^{-1}$ during 1991 (Prepas and Burke, In press), when Chironomus spp. were most abundant. Maximum densities of Chironomus spp. in Amisk Lake never exceeded $8000 \cdot m^{-2}$ at any sampling depth.

In summary, this study suggests that individual Chironomus species respond to hypolimnetic oxygenation in their own fashion. Dissolved oxygen concentrations, rather than water temperature, were the primary factor limiting C. anthracinus populations in the profundal region of Amisk Lake. Although a large potential food base was developed, exploitation by the resident fish community may have been hampered because a large proportion of the food base was located outside of preferred DO and temperature foraging ranges. This study underlines the importance of long-term data collection in northern temperate lakes to fully assess treatment impacts on insects such as Chironomus spp. that have long life cycles and may take several years to respond.

Table 3.1. Mean open-water (May-November) Chironomus spp. larval, pupal and total biomass ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the north basin (North Amisk) and the south basin (South Amisk) of Amisk Lake, and the south basin (South Baptiste) of Baptiste Lake, 1988-1991. South Amisk whole-basin (1988-1991) and near- and far-end (1990-1991) biomass estimates are included.

Year	C. anthracinus	C. cucini	C. decorus	C. plumosus gp.	Early instar larvae	Pupae	Total biomass
North Amisk							
1988	44 ± 40	21 ± 6	29 ± 10	5 ± 5	7 ± 3	23 ± 0	108 ± 41
1989	627 ± 164	53 ± 14	183 ± 65	37 ± 12	0	0	900 ± 198
1990	645 ± 316	107 ± 28	178 ± 54	98 ± 33	58 ± 37	72 ± 5	1099 ± 318
1991	4802 ± 315	643 ± 58	303 ± 85	147 ± 40	0	234 ± 89	6015 ± 333
South Amisk (whole basin)							
1988	14 ± 7	80 ± 18	33 ± 9	6 ± 4	1 ± 1	0	134 ± 24
1989	40 ± 23	64 ± 36	36 ± 11	0	0	0	140 ± 52
1990	163 ± 67	125 ± 27	26 ± 5	3 ± 2	19 ± 10	16 ± 7	338 ± 84
1991	1773 ± 185	1377 ± 186	25 ± 10	1 ± 1	0	21 ± 12	3182 ± 271

Table 3.1 (concl.)

Year	C. anthracinus	C. cucini	C. decorus	C. plumosus gp.	Early instar larvae	Pupae	Total biomass
South Amisk (near end)							
1990	189 ± 86	187 ± 52	34 ± 9	1 ± 1	31 ± 18	20 ± 7	446 ± 122
1991	1678 ± 330	111 ± 53	48 ± 18	1 ± 1	0	14 ± 14	1840 ± 369
South Amisk (far end)							
1990	136 ± 57	63 ± 15	18 ± 8	4 ± 4	7 ± 4	13 ± 8	231 ± 64
1991	1873 ± 264	2612 ± 370	6 ± 4	1 ± 1	0	63 ± 21	4506 ± 556
South Baptiste							
1988	0	9 ± 7	0	164 ± 39	0	0	173 ± 40
1989	0	2 ± 2	0	7 ± 5	0	0	9 ± 5
1990	0	17 ± 5	0	138 ± 20	0	0	155 ± 21
1991	0	0	0	123 ± 59	0	0	123 ± 59

Table 3.2. Mean open-water (May-November) Chironomus spp. larval and pupal weights (mg unpreserved dry weight) ± SE at 25 m in the north basin (North Amisk) and the south basin (South Amisk) of Amisk Lake, and the south basin (South Baptiste) of Baptiste Lake, 1988-1991. Blanks indicate no larvae or pupae were collected.

Year	C. anthracinus	C. cucini	C. decorus	C. plumosus gp.	Early instar larvae	Pupae
North Amisk						
1988	1.48 ± 0.47	1.83 ± 0.26	1.20 ± 0.24	4.39 ± 4.39	0.15 ± 0.04	2.18 ± 2.18
1989	2.53 ± 0.15	2.12 ± 0.32	1.12 ± 0.15	3.71 ± 0.56		
1990	0.84 ± 0.16	1.01 ± 0.19	1.23 ± 0.20	3.14 ± 0.46	0.27 ± 0.05	1.82 ± 0.10
1991	2.86 ± 0.09	2.33 ± 0.09	1.08 ± 0.13	2.83 ± 0.49		1.63 ± 0.15
South Amisk						
1988	1.19 ± 0.34	1.84 ± 0.25	1.15 ± 0.11	2.86 ± 0.74	0.10 ± 0.07	
1989	1.64 ± 0.25	1.51 ± 0.27	1.25 ± 0.10			
1990	0.51 ± 0.50	0.87 ± 0.24	1.20 ± 0.14	0.68 ± 0.31	0.15 ± 0.03	1.52 ± 0.68
1991	1.68 ± 0.12	1.65 ± 0.15	0.69 ± 0.17	0.91 ± 0.52		1.13 ± 0.08
South Baptiste						
1988		2.30 ± 0.70		4.63 ± 0.17		
1989		1.05 ± 0.95		2.75 ± 0.75		
1990		2.01 ± 0.20		4.06 ± 0.38		
1991				5.38 ± 1.04		

Table 3.3. Summary of paired t-tests for Chironomus spp. larval weights in the north basin (North Amisk) and the south basin (South Amisk) of Amisk Lake, and the south basin (South Baptiste) of Baptiste Lake at 15-, 20- and 25-m sampling intervals, 1988-1991. n = number of paired sampling dates. P = statistical probability. '*' indicate significant differences between basins at P = 0.01. Blanks indicate insufficient data were available for a t-test.

	North Amisk & South Amisk		North Amisk & South Baptiste		South Amisk & South Baptiste	
Year	n	P	n	P	n	P
C. anthracinus						
1988	3	0.07				
1989	6	< 0.001*				
1990	5	< 0.01*				
1991	13	< 0.001*				
C. cucini						
1988	6	0.53				
1989	5	0.02				
1990	10	0.25	6	0.01*	7	0.02
1991	13	< 0.001*				
C. decorus						
1988	8	0.54				
1989	6	> 0.90				
1990	9	0.52				
1991	9	0.10				
C. plumosus group						
1988						
1989						
1990			8	0.09		
1991			5	0.10		

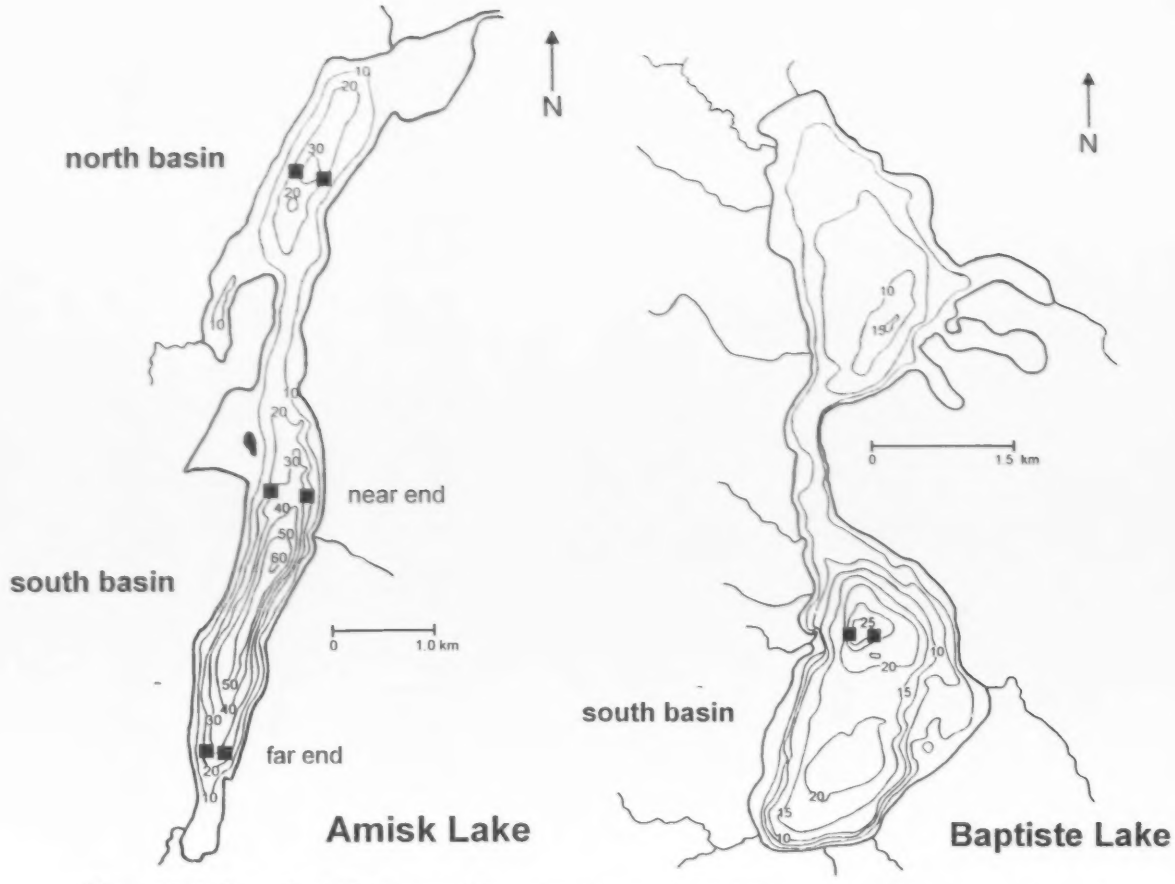

Figure 3.1. Location of sites used in estimating profundal Chironomus biomass and larval weights in the north (North Amisk) and south (South Amisk) basins of Amisk Lake and the south (South Baptiste) basin of Baptiste Lake, Alberta. Contours are in m.

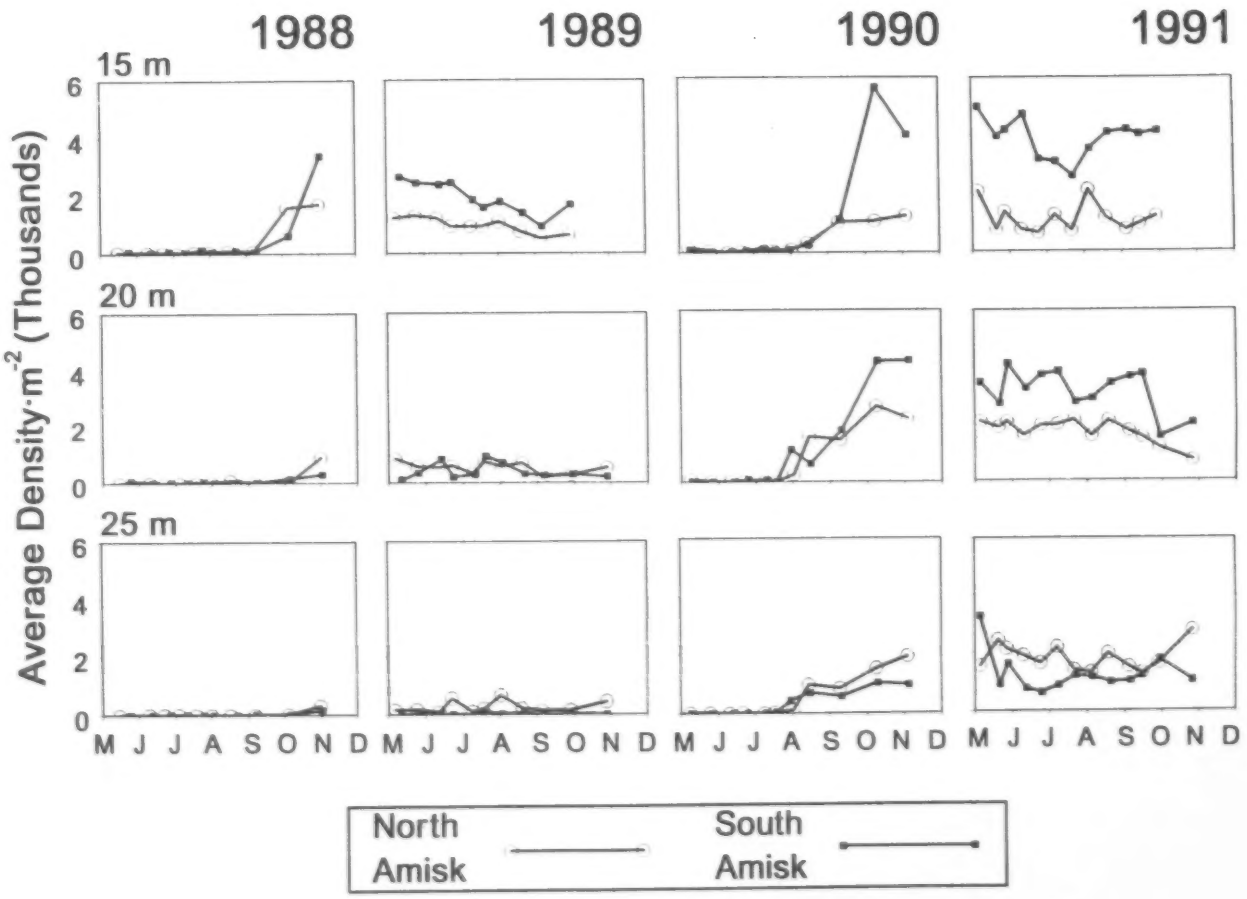

Figure 3.2. Mean densities (no.·m^{-2}) of Chironomus anthracinus larvae collected during the open-water season (May-November) at 15-, 20-, and 25-m (± 2.5 m) intervals in the north basin (North Amisk) and the south basin (South Amisk) of Amisk Lake, 1988-1991.

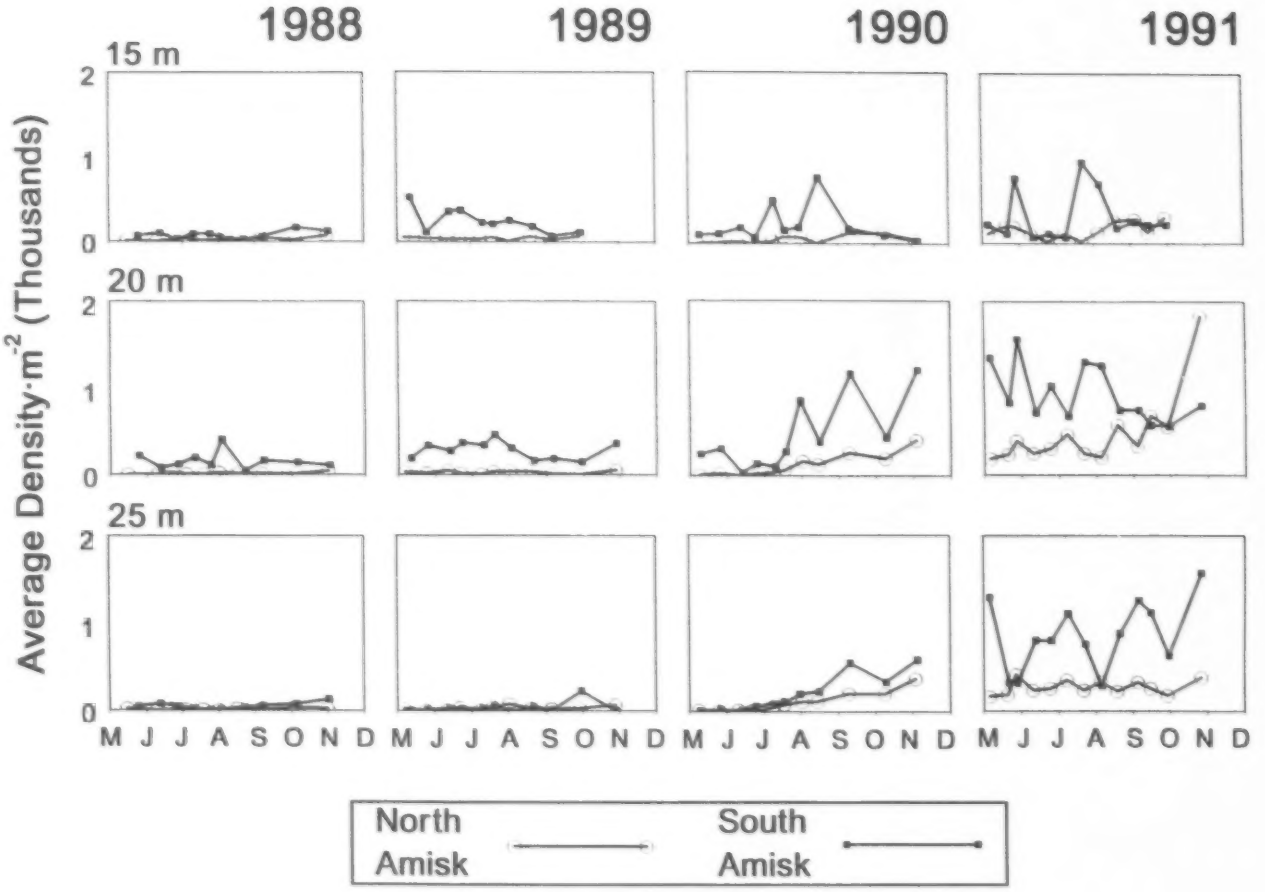

Figure 3.3. Mean densities (no.·m^{-2}) of Chironomus cucini larvae collected during the open-water season (May-November) at 15-, 20-, and 25-m (± 2.5 m) intervals in the north basin (North Amisk) and the south basin (South Amisk) of Amisk Lake, 1988-1991.

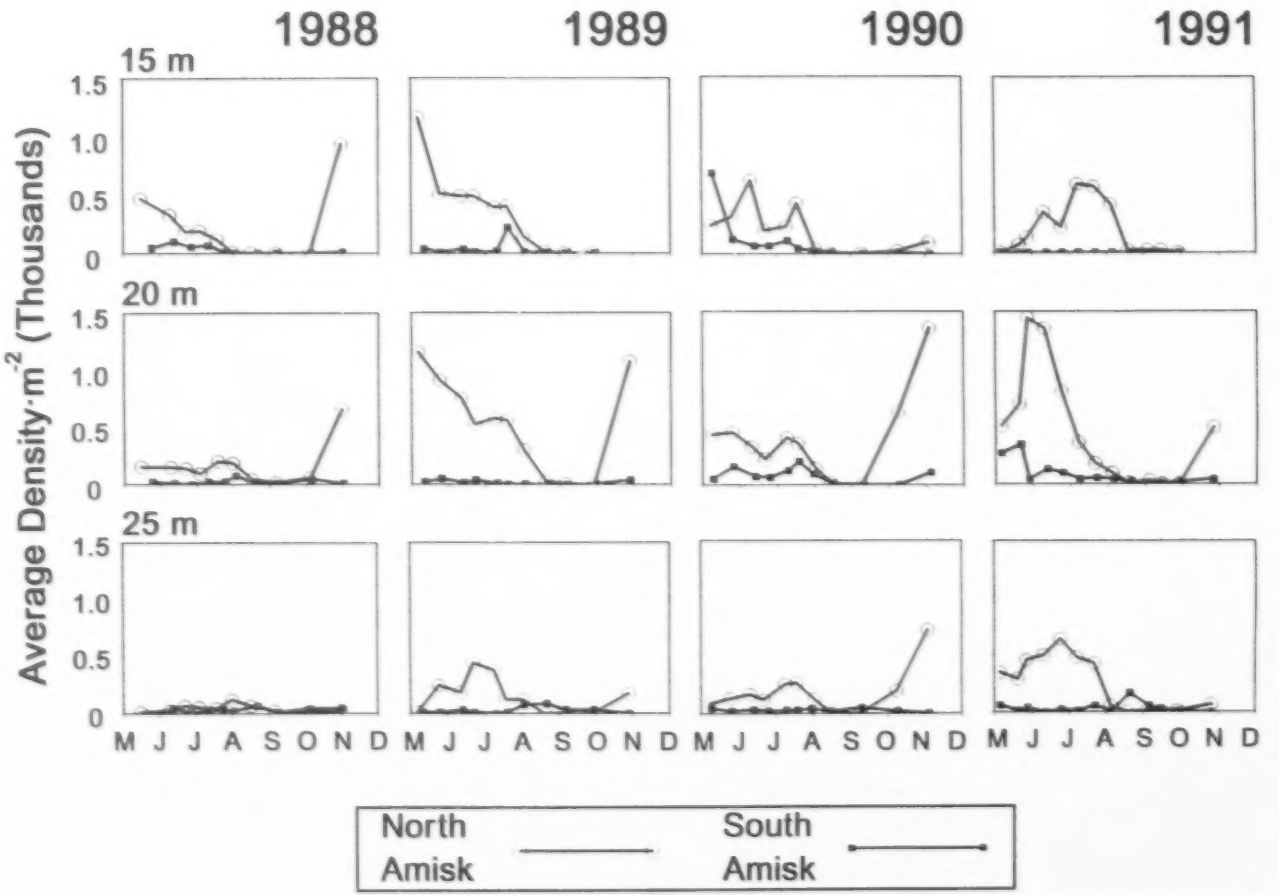

Figure 3.4. Mean densities (no.·m^{-2}) of Chironomus decorus larvae collected during the open-water season (May-November) at 15-, 20-, and 25-m (± 2.5 m) intervals in the north basin (North Amisk) and the south basin (South Amisk) of Amisk Lake, 1988-1991.

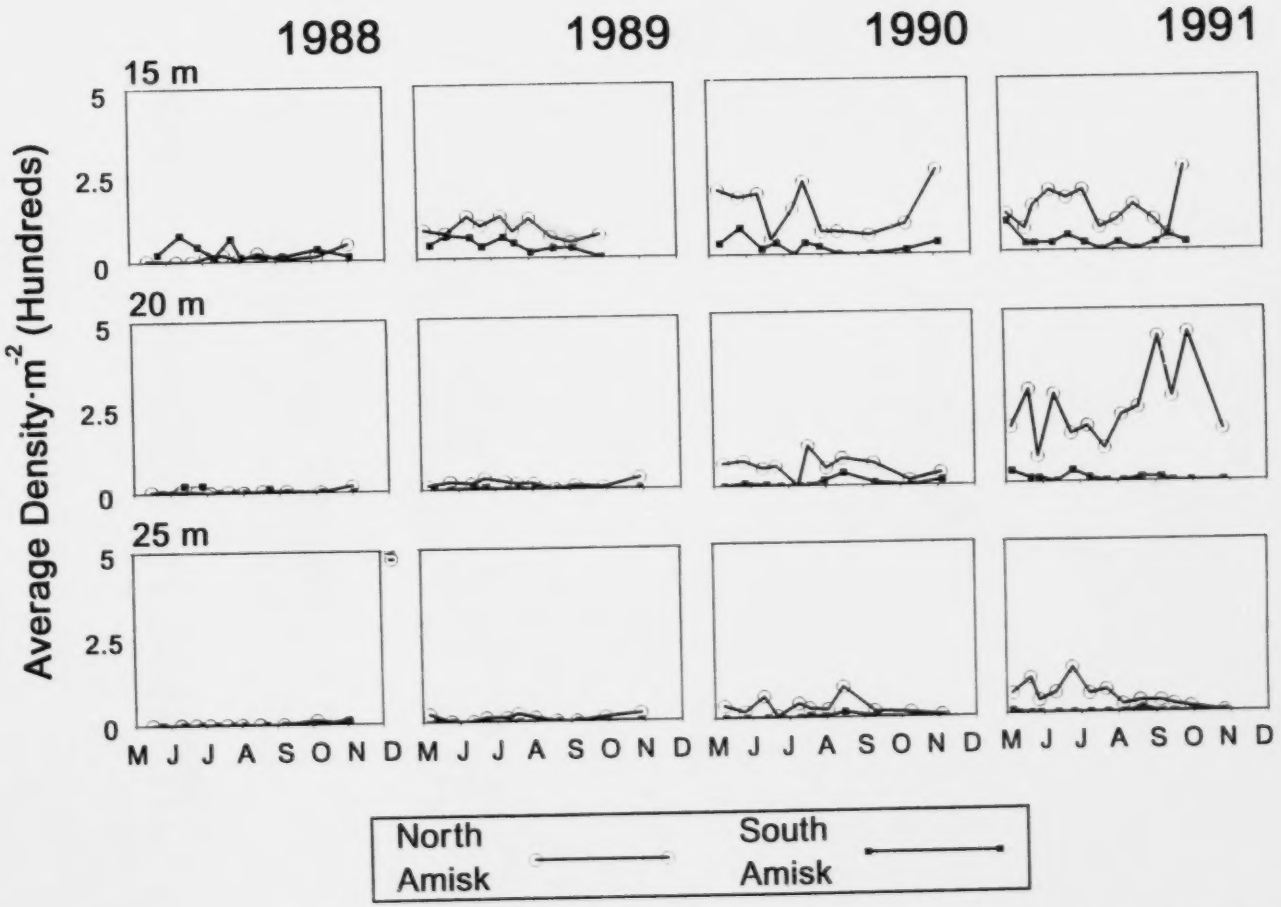

Figure 3.5. Mean densities (no.·m^{-2}) of Chironomus plumosus group larvae collected during the open-water season (May-November) at 15-, 20-, and 25-m (± 2.5 m) intervals in the north basin (North Amisk) and the south basin (South Amisk) of Amisk Lake, 1988-1991.

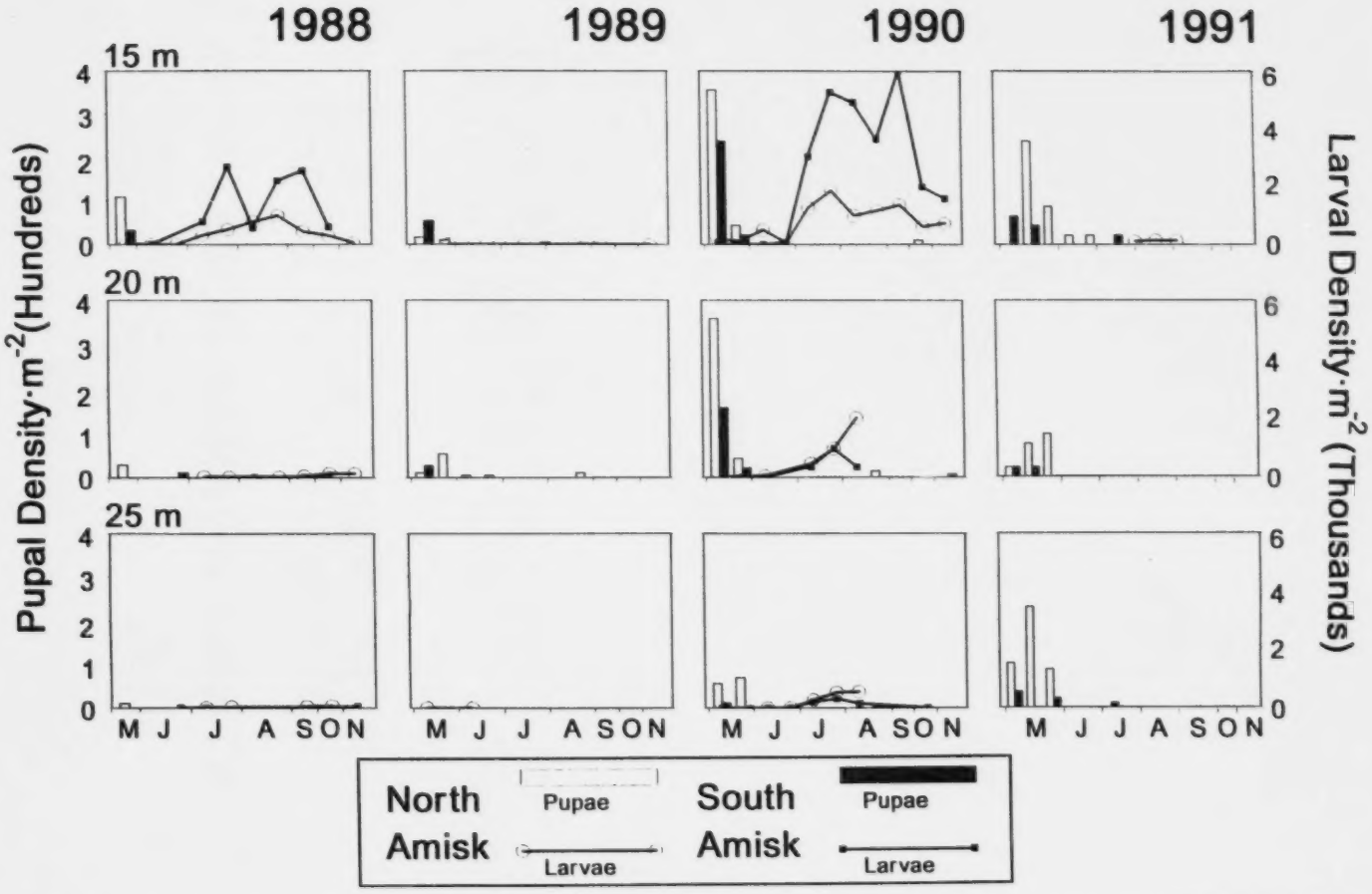

Figure 3.6. Mean densities (no.·m^{-2}) of early instar Chironomus spp. larvae (lines) and Chironomus spp. pupae (bars) collected during the open-water season (May-November) at 15-, 20-, and 25-m (± 2.5 m) intervals in the north basin (North Amisk) and the south basin (South Amisk) of Amisk Lake, 1988-1991.

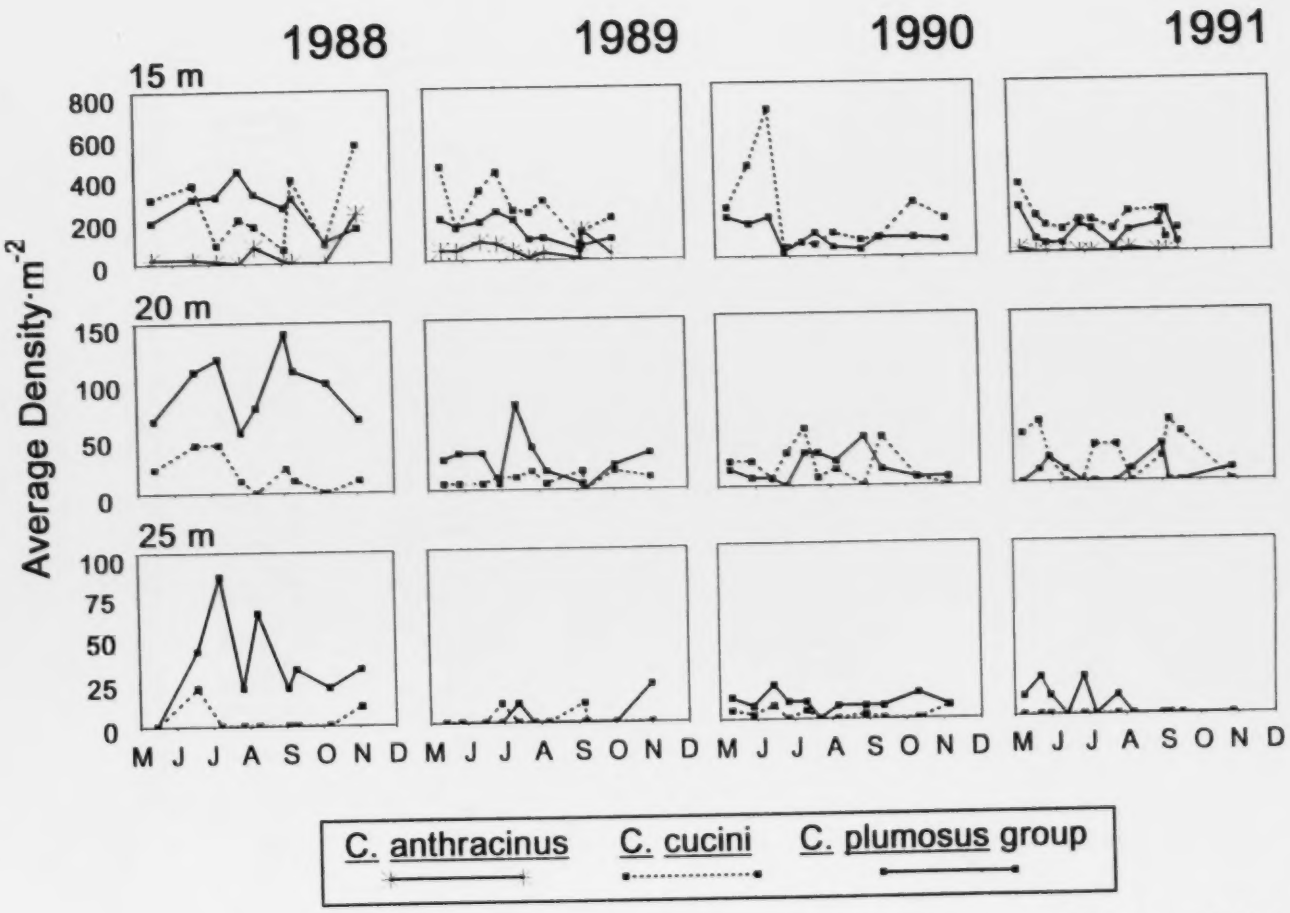

Figure 3.7. Mean densities (no.·m^{-2}) of Chironomus spp. larvae collected during the open-water season (May-November) at 15-, 20-, and 25-m (± 2.5 m) intervals in the south basin of Baptiste Lake (South Baptiste), 1988-1991. Chironomus anthracinus was only present at 15 m. Note the different scales.

3.5. References

Aku, P.M.K., L.G. Rudstam, and W.M. Tonn. In press. Impact of hypolimnetic oxygenation on the vertical distribution of cisco (Coregonus artedi) in Amisk Lake, Alberta. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Bairlein, F. 1989. The respiration of Chironomus-larvae (Diptera) from deep and shallow waters under environmental hypoxia and at different temperatures. Arch. Hydrobiol. 115: 523-536.

Bay, E.C., A.A. Ingram, and L.D. Anderson. 1966. Physical factors influencing chironomid infestation of water-spreading basins. Ann. Entomol. Soc. Am. 59: 714-717.

Brundin, L. 1951. The relation of oxygen- microstratification at the mud surface to the ecology of the profundal bottom fauna. Rep. Inst. Freshwater Res. Drottningsholm 32: 32-42.

Butler, M.G., I.I. Kiknadze, J.K. Cooper, and M. Siirin. In press. Cytologically identified Chironomus species from lakes in North Dakota and Minnesota, USA. In P. Cranston [ed.] Chironomids: from genes to ecosystems. Proceedings of the 12th International Symposium on Chironomidae. CSIRO Publ. Melbourne.

Butler, M.G., and A.M. McMillan. 1990. Cohort structure and voltinism in two profundal Chironomus populations. Verh. Internat. Verein. Limnol. 24: 438-444.

Cowell, B.C., C.J. Dawes, W.E. Gardiner, and S.E. Scheda. 1987. The influence of whole lake aeration on the limnology of a hypereutrophic lake in central Florida. Hydrobiologia 148: 3-24.

Davies, B.R. 1976. The dispersal of Chironomidae larvae: a review. J. Ent. Soc. Sth. Afr. 39: 39-62.

Dermott, R.M., J. Kalff, W.C. Leggett, and J. Spence. 1977. Production of Chironomus, Procladius and Chaoborus at different levels of phytoplankton biomass in Lake Memphremagog, Quebec-Vermont. J. Fish. Res. Board Can. 34: 2001-2007.

Dinsmore, W.P., and E.E. Prepas. 1993. Changes in macroinvertebrate diversity in a deep eutrophic lake undergoing hypolimnetic oxygen injection, with particular reference to Chironomus spp. (Chironomidae). Verh. Internat. Verein. Limnol. 25: 302-306.

Dinsmore, W.P., and E.E. Prepas. In press. The impact of hypolimnetic oxygenation on profundal macroinvertebrates of a eutrophic lake in central Alberta. I. Changes in macroinvertebrate abundance and diversity. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Fast, A.W. 1971. The effects of artificial aeration on lake ecology. Ph.D. Thesis, Michigan State Univ., E. Lansing MI.

Frenzel, P. 1990. The influence of chironomid larvae on sediment oxygen microprofiles. Archiv fur Hydrobiol. 119: 427-438.

Fukuhara, H., and M. Sakamoto. 1987. Enhancement of inorganic nitrogen and phosphate release from lake sediment by tubificid worms and chironomid larvae. Oikos 48: 312-320.

Heinis, F. 1993. Oxygen as a factor controlling occurrence and distribution of chironomid larvae. Ph.D. Thesis, Universiteit van Amsterdam, Amsterdam, The Netherlands.

Heinis, F., and T. Crommentuijn. 1992. Behavioral responses to changing oxygen concentrations of deposit feeding chironomid larvae (Diptera) of littoral and profundal habitats. Arch. Hydrobiol. 124: 173-185.

Heinis, F., W.J. van de Bund, and C. Davids. 1989. Avoidance of low oxygen and food concentrations by the larvae of Tanytarsus sp. Acta Biol. Debr. Oecol. Hung. 3: 141-145.

Hilsenhoff, W.L. 1966. The biology of Chironomus plumosus (Diptera: Chironomidae) in Lake Winnebago, Wisconsin. Ann. Entomol. Soc. Am. 59: 465-473.

Johnson, R.K. 1987. Seasonal variation in diet of Chironomus plumosus (L.) and C. anthracinus Zett. (Diptera: Chironomidae) in mesotrophic Lake Erken. Freshwater Biol. 17: 525-532.

Jónasson, P.M. 1970. Population studies on Chironomus anthracinus. Proc. Adv. Study Inst. Dynamics Numbers Popul. (Oosterbeck, 1970): 220-231.

Jónasson, P.M. 1978. Zoobenthos of lakes. Verh. Internat. Verein. Limnol. 20: 13-37.

Kajak, Z. 1987. Determinants of maximum biomass of benthic Chironomidae (Diptera). Ent. Scand. Suppl. 29: 303-308.

Lawrence, G.A., J.M. Burke, T.P. Murphy, and E.E. Prepas. In press. Exchange flows between the two basins of Amisk Lake. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Lindeberg, B., and T. Wiederholm. 1979. Notes on the taxonomy of European species of Chironomus (Diptera: Chironomidae). Ent. scand. Suppl. 10:99-116.

Martin, J. 1979. Chromosomes as tools in taxonomy and phylogeny of Chironomidae (Diptera). Ent. scand. Suppl. 10:67-74.

McQueen, D.J., and D.R.S. Lean. 1986. Hypolimnetic aeration: an overview. Water Poll. Res. J. Can. 21: 205-217.

Nagell, B., and C.C. Landahl. 1978. Resistance to anoxia of Chironomus plumosus and Chironomus anthracinus (Diptera) larvae. Holarct. Ecol. 1: 333-336.

Oliver, D.R. 1971. Life history of the Chironomidae. Ann. Rev. Entomol. 16: 211-230.

Oliver, D.R., M.E. Dillon, and P.S. Cranston. 1990. A catalog of Nearctic Chironomidae. Agriculture Canada Publ. 1857/B. 89 p.

Pastorok, R.A., T.C. Ginn, and M.W. Lorenzen. 1980. Review of aeration/circulation for lake management. p. 124-133. In Restoration of Lakes and Inland Waters. EPA 440/5-81-010. U.S. Envir. Prot. Ag., Washington D.C.: 562 p.

Pinder, L.C.V. 1986. Biology of freshwater Chironomidae. Ann. Rev. Entomol. 31: 1-23.

Prepas, E.E. 1990a. Baptiste Lake. p. 122-130. In P. Mitchell and E.E. Prepas [ed.] Atlas of Alberta Lakes. University of Alberta Press, Edmonton, AB. 675 p.

Prepas, E.E. 1990b. Amisk Lake. p. 225-231. In P. Mitchell and E.E. Prepas [ed.] Atlas of Alberta Lakes. University of Alberta Press, Edmonton, AB. 675 p.

Prepas, E.E., and J.M. Burke. In press. Hypolimnetic oxygen injection as a method of improving water quality in lakes with large internal inputs of phosphorus. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Saether, O.A. 1979. Chironomid communities as water quality indicators. Holarct. Ecol. 2: 65-74.

Sikorowa, A. 1978. Changes of the distribution and number of the bottom fauna as an effect of artificial lake aeration. Verh. Internat. Verein. Limnol. 20: 1000-1003.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry. 2nd. ed. W.H. Freeman and Co., NY. 859 p.

Takada, K., and K. Kato. 1991. Benthic oxygen consumption in Lake Suwa. Verh. Internat. Verein. Limnol. 24: 1091-1094.

Tatrai, I. 1988. Experiments on nitrogen and phosphorus release by Chironomus ex gr. plumosus from the sediments of Lake Balaton, Hungary. Int. Revue ges. Hydrobiol. 73: 627-640.

Thienemann, A. 1954. Chironomus. Leben, Verbreitung und wirtshaftsliche Bedeutung der Chironomiden. Binnengewässer 20: 1-834.

4. Hypolimnetic dissolved oxygen concentrations as a predictor of profundal macroinvertebrate biomass in eutrophic lakes.

4.1. Introduction

Correlative models to predict changes in profundal macroinvertebrate biomass (PMB) are needed to better understand trophic dynamics in lakes. Previous studies have relied on trophic status indices (chlorophyll a and total phosphorus (TP) concentrations, and Secchi transparency), and morphometric variables (mean and maximum depth, and bottom slope) to account for the majority of variation in PMB in predominantly oligotrophic systems (Hanson and Peters 1984; Rasmussen and Kalff 1987). Multivariate models combining epilimnetic chlorophyll a concentration and non-trophic variables (sampling depth, mean depth, mean:maximum depth ratio, bottom slope, colour, and mean annual air temperature) explained more variation in PMB (R^2 = 0.70-0.72; Rasmussen and Kalff 1987) than models combining epilimnetic TP and morphometric variables (surface area, mean depth, and maximum depth; R^2 = 0.54-0.59; Hanson and Peters 1984). The above studies chose limnological variables that were hypothetically linked with PMB, or were reasonable proxies for other, less accessible variables. For example, Rasmussen and Kalff (1987) hypothesized that the negative correlations of PMB with phytoplankton biomass, Secchi transparency, colour, and sampling depth more properly reflected the deleterious effects of decreased hypolimnetic dissolved oxygen (DO) concentrations on profundal macroinvertebrates.

Dissolved oxygen (DO) is essential for metabolism in all aerobic aquatic organisms (Berg et al. 1962; Herreid 1980). Hypolimnetic DO regimes vary widely between lakes and between seasons and years within lakes (Cornett and Rigler 1987). DO is not critical to macroinvertebrates in well-oxygenated water, relative to food availability (Saether 1979), but profundal macroinvertebrates in productive lakes often suffer stress or mortality from anoxic conditions (DO concentrations $\leq$ 1 $mg \cdot L^{-1}$) during stagnation (Brundin 1951; Jónasson 1978). In these lakes, PMB may decline substantially or

completely from the upper profundal region to maximum depth (Brundin 1951; Brinkhurst 1974). Enhanced hypolimnetic DO concentrations in highly productive lakes are often followed by dramatic increases in macroinvertebrate abundance (Pastorok et al. 1980; Dinsmore and Prepas, In press).

Limiting or critical DO concentrations for profundal macroinvertebrates vary widely among taxa and populations (Davis 1975; Herreid 1980). Attempts to devise a lake typology for macroinvertebrate and chironomid taxa assemblages, based on trophic status and DO concentrations, have met with varying degrees of success (Brinkhurst 1974; Saether 1979). Hanson and Peters (1984), when collecting data for their analyses, omitted water bodies prone to DO depletion to avoid additional residual variation. Rasmussen and Kalff (1987) suggested that DO concentrations were an important determinant of PMB. However, the potential of DO concentrations as a predictor of PMB has never been evaluated directly in an empirical model.

In addition, there are aspects of the established relationships between PMB and trophic indices that remain unclear. Rasmussen and Kalff (1987) found a parabolic relationship between PMB and chlorophyll a in their predominantly oligotrophic lakes; maximum PMB was predicted at chlorophyll a concentrations of 11$\mu g \cdot L^{-1}$ but decreased with further increases in chlorophyll a. However, although chlorophyll a and TP concentrations are highly correlated (Smith 1979; Prepas and Trew 1983), Hanson and Peters (1984) and Rasmussen and Kalff (1987) suggest that the relationship between PMB and TP is linear. Hypothetically, the relationship between PMB and TP concentrations should be a parabolic function similar to that between PMB and chlorophyll a. Takamura and Iwakuma (1990) suggest that PMB is depressed in lakes with TP concentrations > 100 $\mu g \cdot L^{-1}$. The relationship between PMB and trophic indices should be re-evaluated for lakes with high levels of primary productivity.

Precise measurements of DO concentrations at profundal macroinvertebrate sampling depths are needed to determine the relationship of DO with PMB. The purpose of this study was to evaluate the effectiveness of DO and a suite of trophic, morphometric and water quality parameters to predict PMB in a data set of predominantly eutrophic

lakes (mean epilimnetic TP concentrations > 35 $\mu g \cdot L^{-1}$; Mitchell and Prepas 1990) in Alberta, Canada. I hypothesized that PMB would be strongly correlated with low DO concentrations (0-4 $mg \cdot L^{-1}$), but weakly or noncorrelated with DO concentrations > 4 $mg \cdot L^{-1}$.

4.2. Methods

All lakes for which open-water (May-November) PMB ($g \cdot m^{-2}$ wet weight) data could be coupled with key limnological variables (Table 4.1) were included (Appendix E). Data were compiled from 26 studies on 32 lakes, of which 7 (Chestermere, Upper and Lower Kananaskis, McGregor, Newell, Reesor and Spray) are reservoirs. Three lakes (Amisk, Lac Ste. Anne and Skeleton) have 2 distinct basins. All lakes are situated between 56° and 49°N and represent 8 of the 12 ecoregions of Alberta (Strong and Leggat 1981; Appendix). The majority of lakes (29 of 32) are moderately to highly productive, and consisted of 3 oligotrophic (summer epilimnetic TP concentrations < 10 $\mu g \cdot L^{-1}$), 13 mesotrophic (10-35 $\mu g \cdot L^{-1}$ TP), 12 eutrophic (35-100 $\mu g \cdot L^{-1}$ TP), and 4 hypereutrophic systems (> 100 $\mu g \cdot L^{-1}$ TP; Mitchell and Prepas 1990). Except for slightly saline Eagle (specific conductivity 1828 $\mu S \cdot cm^{-1}$), Gull (1144 $\mu S \cdot cm^{-1}$) and Sylvan (597 $\mu S \cdot cm^{-1}$) lakes, all lakes in the data set have conductivities < 500 $\mu S \cdot cm^{-1}$ (Mitchell and Prepas 1990). Colour in Alberta lakes is typically low to moderate (mean freshwater colour: 13 mg $Pt \cdot L^{-1}$; mean saline colour: 35 mg $Pt \cdot L^{-1}$; Mitchell and Prepas 1990).

Profundal macroinvertebrates were defined as those collected from depths greater than the maximum depth of macrophyte colonization. The latter was estimated for each lake with an empirical model for lakes of low colour (Chambers and Prepas 1988). This definition of profundal macroinvertebrates also included macroinvertebrates collected from the sublittoral region. Mean open-water PMB estimates from a particular lake were considered independent if sampled at two or more discrete depths within distinct basins, and if estimates were available for more than one year. A total of 92 PMB estimates were obtained from the 32 lakes. The 26 studies that generated PMB data varied in sampling

protocol and attention to detail in reporting of methods. For instance, samples were collected after 1960 with Ekman-Birge grabs, whereas pre-1960 samples were collected by "dredging". Only 9 of the 26 studies reported the mesh size used for sieving, which ranged from 200 to 800 μm. Samples were preserved in 2, 4, or 10% formalin (10 studies), 70% ETOH (2 studies), or 70% isopropyl alcohol (1 study); 13 studies did not report the preservative used. PMB sampling intervals ranged from once to weekly during the open-water season. Biomass expressed as dry weight was converted to wet weight by dividing by 0.15 (Rasmussen and Kalff 1987) or by the conversion factor reported by the particular study. Biomass expressed as biovolume (mL or cc) was converted to wet weight by multiplying by 1.06, after Smit et al. (1993).

Mean and minimum open-water DO concentrations, and mean and maximum open-water temperatures were estimated by Winkler titration and thermistor, respectively, for the same depths sampled for PMB, or as close to that depth as possible. The length of the anoxic period was defined as the number of weeks that DO concentrations were ≤ 1 $mg \cdot L^{-1}$ at the PMB sampling depth (Nürnberg 1987; Heinis 1993). DO and water temperature were typically estimated at monthly (17 lakes), twice monthly (7 lakes), or weekly intervals (2 lakes). In the remaining 6 lakes, DO and temperature were determined < 4 times per year, so data from 2 or more years were averaged. I attempted to link PMB data with DO and water temperature data collected as close to the year of PMB sampling as possible. DO concentrations and temperature were measured concurrently with PMB (2 studies), within 1-10 yr of PMB collection (9 studies), 11-20 yr (7 studies), 21-30 yr (3 studies), and 31-40 yr after PMB collection (4 studies). The most extreme interval was for the Upper and Lower Kananaskis lakes, where DO and temperature data were collected 47 yr after PMB was estimated. The mean interval between PMB and DO estimation for all lakes in the data set was 14 ± 2 yr. I assumed that lake conditions had remained similar during the intervening years. However, for the purpose of regressional analysis, the amount of variation in PMB explained by DO and water temperatures would be considerably improved if these variables were measured concurrently at the same location, using standardized, rigorous methodology.

Data for trophic indices (epilimnetic chlorophyll a and TP concentrations ($\mu g \cdot L^{-1}$), and Secchi transparency (m)) for 29 of the 32 lakes in the data set were obtained from Mitchell and Prepas (1990), whereas trophic variable data for Amisk and Baptiste lakes were obtained from Prepas and Burke (In press). TP and Secchi transparency data for Matchayaw Lake were obtained from Lane (1971), and epilimnetic chlorophyll a was estimated with the empirical model:

(1) $\log \text{chl } a = -0.661 + 1.146 (\log TP)$ $\quad R^2 = 0.81, n = 34$

from Prepas and Trew (1983). Data for specific conductivity ($\mu S \cdot cm^{-1}$), pH, mean and maximum depth (m), mean:maximum depth ratio, and surface area (km^2) were also obtained from Mitchell and Prepas (1990), except for Matchayaw Lake, which were obtained from Lane (1971). The bottom slope (%) of each basin was estimated from bathymetric maps.

Colour (mg $Pt \cdot L^{-1}$) data were available for only 19 of 32 lakes in the data set (Table 4.2). Rasmussen and Kalff (1987) predicted colour from dissolved organic carbon (DOC) concentrations ($mg \cdot L^{-1}$) with the empirical model:

(2) $(\text{colour} + 25)^{0.5} = 4.12 + 0.479 (DOC)$ $\quad R^2 = 0.92, n = 55$

However, this model overestimated colour by an average of 9 times in these lakes (Table 4.2). Exceptions were Chestermere, McGregor and Newell reservoirs, where differences between observed and predicted colour were inconsistent. A new model was generated from an independent data set of 100 colour and DOC estimates from 77 Alberta lakes, located between 56 and 49 N (Appendix E):

(3) $\log \text{colour} = 0.378 + 0.681 (\log DOC)$ $\quad R^2 = 0.40, n = 100$

Colour was estimated for another 9 lakes (Appendix E); no colour or DOC data were available for Upper and Lower Kananaskis, Matchayaw and Spray lakes. No relationship was detected during regressional analysis between PMB and colour, or PMB and DOC for the 28 lakes with colour and DOC data ($\underline{P} > 0.45$ and $\underline{P} > 0.27$, respectively), so colour was not considered as an independent variable in further analyses.

Regression Analyses

Significant ($\underline{P} < 0.05$) relationships between PMB and limnological variables were examined by least squares methods of linear and nonlinear regression, and backwards stepwise multiple regression. Variables other than DO and water temperature (Table 4.1) were transformed as per Rasmussen and Kalff (1987). PMB was transformed to the tenth root, chlorophyll a and specific conductivity were transformed to the square root, Secchi transparency and mean:maximum depth ratio were left untransformed, and all other variables were transformed using natural logarithms. The best fit for mean DO concentration ($mg \cdot L^{-1}$) and mean and maximum temperature (°C) was provided by $\log_{10}$ transformation. Minimum DO concentration and anoxic period (wk) were transformed by $\log_{10}(X_i + 1)$, because zero values were present.

The relationships between PMB ($(g \cdot m^{-2})^{0.1}$) and chlorophyll a ($(\mu g \cdot L^{-1})^{0.5}$), TP (ln ($\mu g \cdot L^{-1}$)), and Secchi transparency (m) were examined using univariate regression. The Alberta lake data set was first tested alone, then combined with the data sets of Hanson and Peters (1984) and Rasmussen and Kalff (1987). No chlorophyll a data were available from Hanson and Peters (1984). The significance of second power terms was tested for chlorophyll a and TP concentrations in nonlinear regressions, for both the Alberta lake and combined data sets. The relationships of Alberta PMB to average and minimum DO concentrations, anoxic period, and mean and maximum water temperatures were also tested in univariate linear and nonlinear regressions. The trophic, DO and temperature parameters explaining the most variation in PMB in univariate models, as measured by $\underline{R}^2$ (adjusted for degrees of freedom), were entered along with the non-trophic variables assembled into multiple regression models. Models were produced by backwards stepwise

selection and used as variable entry and removal criteria the probability of $\underline{F} = 0.05$ and $\underline{F} = 0.1$, respectively. SPSS for Windows version 6.0 was used for all analyses.

4.3. Results

Trophic indices were weak predictors of PMB in the predominantly eutrophic lakes of the Alberta data set. TP and chlorophyll a concentrations explained only 11% and 12%, respectively, of PMB variance in linear models ($\underline{P} < 0.001$), and the relationship between PMB and Secchi transparency was nonsignificant ($\underline{P} > 0.70$). Further, the power terms for both chlorophyll a and TP were nonsignificant ($\underline{P} > 0.72$ and 0.40, respectively). In the combined data set (Fig. 4.1), both the linear and parabolic relationships of PMB with chlorophyll a were highly significant ($\underline{P} < 0.001$), but the parabolic regression explained slightly more variation (37%) than the linear regression (30%). The parabolic relationship predicted maximum PMB at 23 $\mu g \cdot L^{-1}$ chlorophyll a. The rate of decline in PMB above this level was less than that observed in Rasmussen and Kalff's (1987) model. In contrast, the relationship between PMB and TP (Fig. 4.2) remained linear in the combined data set, and the amount of explained variance was lower than for chlorophyll a (25%; $\underline{P} < 0.001$).

Anoxic period had no detectable influence on PMB from either the entire Alberta data set ($\underline{P} > 0.05$), or from a data subset where anoxic period was $\geq$ 1 wk ($\underline{P} > 0.17$). Mean DO concentration was also unrelated to PMB ($\underline{P} > 0.11$). In contrast, the relationship of minimum DO and PMB from the entire Alberta data set (Fig. 4.3) was highly significant ($\underline{P} < 0.001$) as a parabolic function. Maximum PMB was predicted at minimum DO concentrations of 2 to 3 $mg \cdot L^{-1}$, and the model explained 18% of PMB variance. Minimum DO explained 38% of variation ($\underline{P} < 0.001$) in a subset of PMB collected at depths where minimum DO was ≤ 4 $mg \cdot L^{-1}$ (Fig. 4.4), but minimum DO had no detectable influence on PMB collected at depths where minimum DO was > 4 $mg \cdot L^{-1}$ ($\underline{P} > 0.11$). These two subsets of the Alberta PMB data set were not related to either chlorophyll a or TP ($\underline{P} > 0.06$).

Mean and maximum water temperature were both significant predictors of PMB ($\underline{P} < 0.001$), explaining 13 and 16% of variation in PMB, respectively. Bottom slope was a superior predictor of PMB (24%; $\underline{P} < 0.001$) compared to mean and maximum depth (16 and 19%, respectively; $\underline{P} < 0.001$), both of which were highly correlated with slope ($\underline{R} > 0.74$).

Only bottom slope and minimum DO concentration were retained during multiple regression analysis of the entire Alberta data set:

(4) $PMB^{0.1} = 1.263 + 0.579 (\log \text{min DO}) - 0.625 (\log \text{min DO})^2 - 0.047 (\ln \text{slope})$
$\underline{R}^2 = 0.28, \underline{n} = 92$

Bottom slope explained most of the variance in PMB (24%), whereas the combined power terms for minimum DO explained only 4%. Minimum DO, bottom slope and specific conductivity were retained during multiple regression analysis of the subset where minimum DO was ≤ 4 mg·L^{-1}:

(5) $PMB^{0.1} = 1.423 + 0.451 (\log \text{min DO}) - 0.054 (\ln \text{slope}) - 0.009 (\text{conductivity})^{0.5}$
$\underline{R}^2 = 0.55, \underline{n} = 42$

Minimum DO explained a high amount of variance in this regression (38%), with significant contributions from slope (12%) and specific conductivity (4%). Chlorophyll *a* and TP concentration were not retained as significant variables in either model.

4.4. Discussion

Minimum DO concentrations were a superior predictor of PMB relative to trophic and morphometric variables in the Alberta lake data set, particularly at sites where concentrations were < 4 mg·L^{-1}. The parabolic relationship between PMB and minimum DO concentrations (Fig. 4.3) suggests that PMB is suppressed in lakes where

hypolimnetic DO demand is high (i.e., low minimum DO). There was no functional relationship between PMB and minimum DO > 4 $mg \cdot L^{-1}$, consistent with the hypothesis that DO concentrations above 4 $mg \cdot L^{-1}$ did not limit PMB. Although food resources are a primary factor determining PMB when hypolimnetic DO concentrations are non-limiting (Saether 1979; Rasmussen and Kalff 1987), there was no relationship between chlorophyll a and PMB collected at sites where minimum DO exceeded 4 $mg \cdot L^{-1}$. Hypolimnetic DO depletion is correlated with trophic indices, but is also influenced by basin morphometry (mean depth) and hypolimnetic water temperature (Cornett and Rigler 1980). The inability of chlorophyll a to account for PMB variation where hypolimnetic DO was non-limiting indicates that other, undetermined factors are responsible for the PMB distribution observed at these collection sites.

Methodological problems, in particular extended time intervals between estimation of PMB and DO concentrations for many lakes in the data set, were of serious concern in this study. Also, infrequent sampling of PMB for several lakes in the data set may have inadequately represented open-water biomass, forming an important source of residual variation (Hanson and Peters 1984). However, minimum DO concentrations were still able to account for a substantial proportion of PMB variation, despite these shortcomings in the data. These results indicate that DO concentrations hold potential as a predictor of PMB in eutrophic lakes. The amount of variation in PMB explained by minimum DO concentrations could be possibly improved if the two parameters were estimated concurrently at the same location, using standardized, rigorous methodology.

The lack of a strong relationship between anoxic period and PMB was surprising. Although many profundal macroinvertebrate taxa can maintain metabolic processes over a wide range of DO concentrations, and can tolerate brief periods of anoxia (Berg et al. 1962; Jónasson 1978), none can survive such conditions indefinitely. Heinis (1993) suggested that anoxic period determined differences in Chironomus anthracinus depth distribution among lakes. The mean anoxic period for the Alberta data set was 4 ± 0.9 wk, within the tolerance limits of taxa such as Chironomus spp. (Nagell and Landahl 1978) and tubificid oligochaetes (Aston 1973). These taxonomic groups contribute the majority of

PMB in most northern temperate eutrophic lakes (Brinkhurst 1974). A short anoxic period may not increase mortality of tolerant macroinvertebrates, but could provide a refugium from fish predation and exclude oxygen-sensitive competitors (Jónasson 1978). Low predation and competitive pressures often result in large accumulations of profundal biomass comparable to those of the littoral region. Some lakes can support large biomasses of Chaoborus spp. at depths with persistent anoxia (Dinsmore and Prepas, In press), presumably because the vertical migratory behaviour of Chaoborus allows them access to epilimnetic DO at night.

Hypolimnetic water temperatures influence oxygen solubility (Cornett and Rigler 1980), and regulate macroinvertebrate metabolism and bacterial activity in the sediments (Berg et al. 1962). However, maximum water temperature was not a significant factor in multiple regression analysis, suggesting that water temperature variation was low between the lakes in this data set.

Rasmussen and Kalff's (1987) relationship between PMB and chlorophyll a concentration was determined from a data set of predominantly oligotrophic lakes, of which 62 of 99 lakes had chlorophyll a concentrations < 4 $\mu g \cdot L^{-1}$, and only 11 had concentrations > 11 $\mu g \cdot L^{-1}$. Alberta data from lakes of moderate to high trophic status (mean chlorophyll a concentration: 15 ± 2 $\mu g \cdot L^{-1}$; Table 4.1) helped to clarify the relationship around the centre of the parabola, but additional data from lakes of high primary productivity (chlorophyll a concentrations > 30 $\mu g \cdot L^{-1}$) are needed to clarify the relationship of PMB to chlorophyll a at that end of the productivity spectrum.

Although the relationship between chlorophyll a and TP concentrations in Alberta lakes is strong (Prepas and Trew 1983), my data were not consistent with the hypothesis that the relationship between PMB and TP should also be parabolic. The link between TP and PMB appeared weak, particularly at TP concentrations > 50 $\mu g \cdot L^{-1}$ (Fig. 4.2). The low PMB observed by Takamura and Iwakuma (1990) in lakes with high TP concentrations may be a consequence of high DO demand from detrital decomposition.

Bottom slope was negatively correlated with PMB and was a useful predictor in the Alberta data set. Fine organic material with high food potential tends to accumulate on

gentler inclines, as reflected by the negative correlation of sediment particle size with slope (Duarte and Kalff 1986). Furthermore, sediment particle size may play an important role in habitat selection for macroinvertebrates. Distribution of Chironomus spp., a major contributor to PMB in many northern temperate lakes (Jónasson 1978; Dinsmore and Prepas, In press), is determined in part by a preference for substrata with particle diameters of < 20 μm (Johnson 1984). The importance of bottom slope in this study suggests that direct measurements of detrital quantity and quality, sediment particle size, and microbial activity may be more effective predictors of PMB in eutrophic lakes than either epilimnetic chlorophyll a and TP estimates.

Specific conductivity, as an indicator of salinity, made a minor contribution to the amount of variance explained for PMB from sites where DO concentrations were < 4 $mg \cdot L^{-1}$. Profundal macroinvertebrate diversity and biomass are negatively correlated with salinity (Williams et al. 1990). Salinity may represent direct inhibitory effects on macroinvertebrate osmoregulation, or indirect effects of persistent hypolimnetic anoxia typical of many saline lakes (Melack 1983). However, the lakes in this study were only of low to moderate salinity. Since the amount of variance in PMB explained by specific conductivity was low (4%), it is questionable whether this variable was of biological significance.

The predictive model for colour developed by Rasmussen and Kalff (1987) was not appropriate for the lakes in this study. Colour in most lakes on the boreal plains is low relative to other regions of North America because annual surface water inflow, and consequently external DOC inputs, is limited (Chambers and Prepas 1988; Curtis and Prepas 1993). In contrast to Rasmussen and Kalff's (1987) data set, where DOC and colour were highly correlated ($R = 0.96$), the correlation between colour and DOC in boreal plains lakes is weaker ($R = 0.63$). The relationship between colour and DOC in boreal plains lakes warrants further investigation.

In summary, the best model generated by this study accounted for over half of the variance in profundal macroinvertebrate biomass of this eutrophic lake data set. Minimum dissolved oxygen concentrations appear to be directly linked with PMB in lakes with low

hypolimnetic DO concentrations. The amount of variance explained by minimum DO was enhanced by bottom slope, likely an indirect estimate of detrital food accumulation and substrate quality, and to a minor extent by specific conductivity. As phytoplankton biomasses increase, hypolimnetic DO concentrations appear to become the dominant factor controlling PMB. Residual variation in all uni- and multivariate models were high, underscoring the need for more reliable estimates of PMB and improved measurements of limnological parameters. However, this study indicates that further exploration of the relationship of PMB to hypolimnetic DO regimes and detrital production and accumulation could enhance our understanding of trophic dynamics in eutrophic lakes.

Table 4.1. Means, standard errors, and ranges of variables used in regression analyses of profundal macroinvertebrate biomass (PMB) from 32 Alberta lakes. Dissolved oxygen (DO) and temperature data are from Alberta Environmental Protection, Water Quality Branch (unpublished data); other data are from Mitchell and Prepas (1990), Lane (1971), and EEP (unpublished data).

Variable	Mean	Standard Error	Range	n
PMB ($g\ m^{-2}$)	22.4	3.3	0.2 - 201.0	92
Chlorophyll *a* ($\mu g\ l^{-1}$)	15	2	0.4 - 46	44
Total Phosphorus ($\mu g\ l^{-1}$)	57	9	4 - 333	41
Secchi Transparency (m)	2.7	0.2	0.4 - 6.3	41
Specific Conductivity ($\mu S\ cm^{-1}$)	375	52	158 - 1828	35
Colour ($mg\ Pt\ l^{-1}$)	15	2	1 - 46	25
DOC ($mg\ l^{-1}$)	12	1	2 - 25	34
pH	8.3	0.1	7.3 - 9.6	35
Slope (%)	3.6	0.8	0.2 - 19.2	35
Area (km^2)	66.2	34.1	0.5 - 1160	34
Zmean (m)	8.2	1.0	1.7 - 32	33
Zmax (m)	21.1	3.6	4.7 - 108	35
Zmean:Zmax	0.45	0.0	0.2 - 0.7	33
Mean DO conc. ($mg\ l^{-1}$)	6.6	0.3	0.4 - 9.7	92
Minimum DO conc. ($mg\ l^{-1}$)	3.9	0.3	0.0 - 8.5	92
anoxic period (wk)	3	0.6	0 - 20	84
Mean Water Temperature (°C)	10.9	0.4	4.2 - 17.6	92
Maximum Water Temperature (°C)	14.3	0.5	4.8 - 20.8	92

Table 4.2. A comparison of observed and predicted colour for 19 Alberta lakes included in this study. Colour was predicted using the model of Rasmussen and Kalff (1987). Unless otherwise referenced, dissolved organic carbon (DOC) and colour data are from Alberta Environmental Protection (unpublished data).

Lake	DOC ($mg \cdot L^{-1}$)	Observed Colour ($mg\ Pt \cdot L^{-1}$)	Predicted Colour ($mg\ Pt \cdot L^{-1}$)
Amisk North	14 b	10 a	92
Amisk South	13 b	10 a	82
Baptiste South 1986	17 a	25 a	125
Baptiste South 1991	23 b	15 b	204
Baptiste South 1992	14 b	12 b	92
Beavais	9	8	46
Calling	10 a	14 a	54
Chestermere Reservoir	2	6	1
Crimson	12	5	72
Eagle	21	42	176
Elkwater	11	19	63
Gull	22	8	190
Isle	23 b	29 b	204
Lesser Slave East	10	14	54
Lesser Slave West	11	19	63
McGregor	2	8	1
Narrow	11 b	8 a	63
Newell 1983	3	6	6
Newell 1993	3	3	6
Pigeon	7	1	31
Reesor	5	7	17
Sturgeon Main	16	21	114
Sturgeon West	19	46	150
Sylvan	8	2	38
Winagami	25	24	234

a Mitchell and Prepas (1990)
b EEP (unpubl. data)

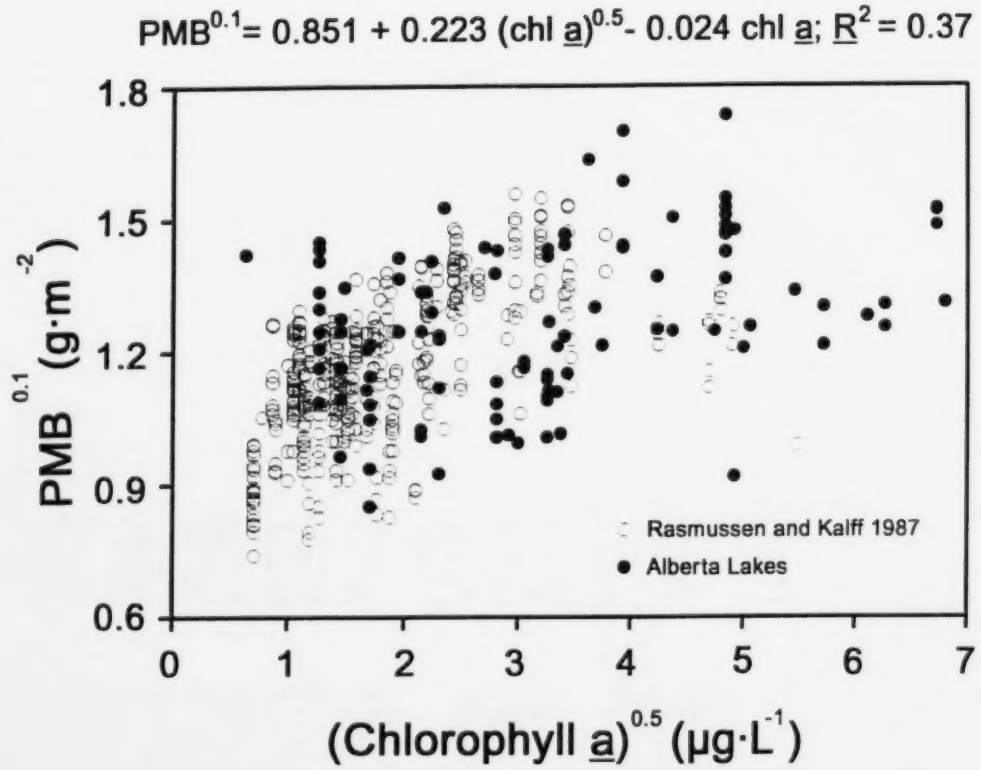

Figure 4.1. Relationship between profundal macroinvertebrate biomass (PMB, wet weight) and chlorophyll a concentration. The combined data are from Rasmussen and Kalff (1987) and this study (Alberta lakes).

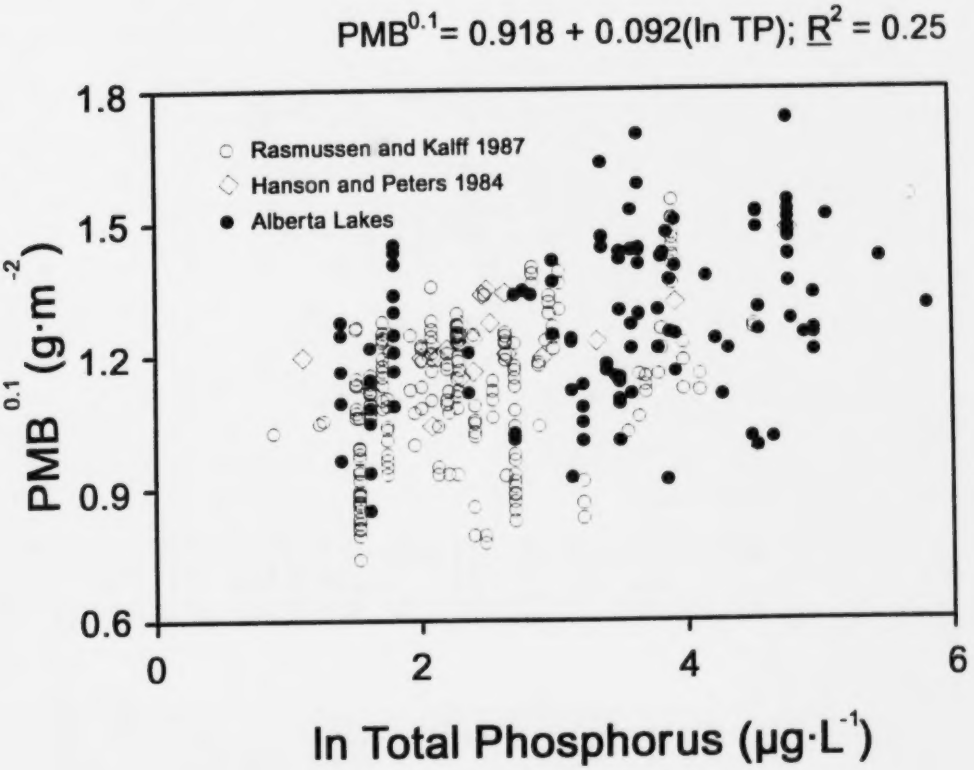

Figure 4.2. Relationship between profundal macroinvertebrate biomass (PMB, wet weight) and total phosphorus concentration. The combined data are from Hanson and Peters (1984), Rasmussen and Kalff (1987), and this study (Alberta lakes).

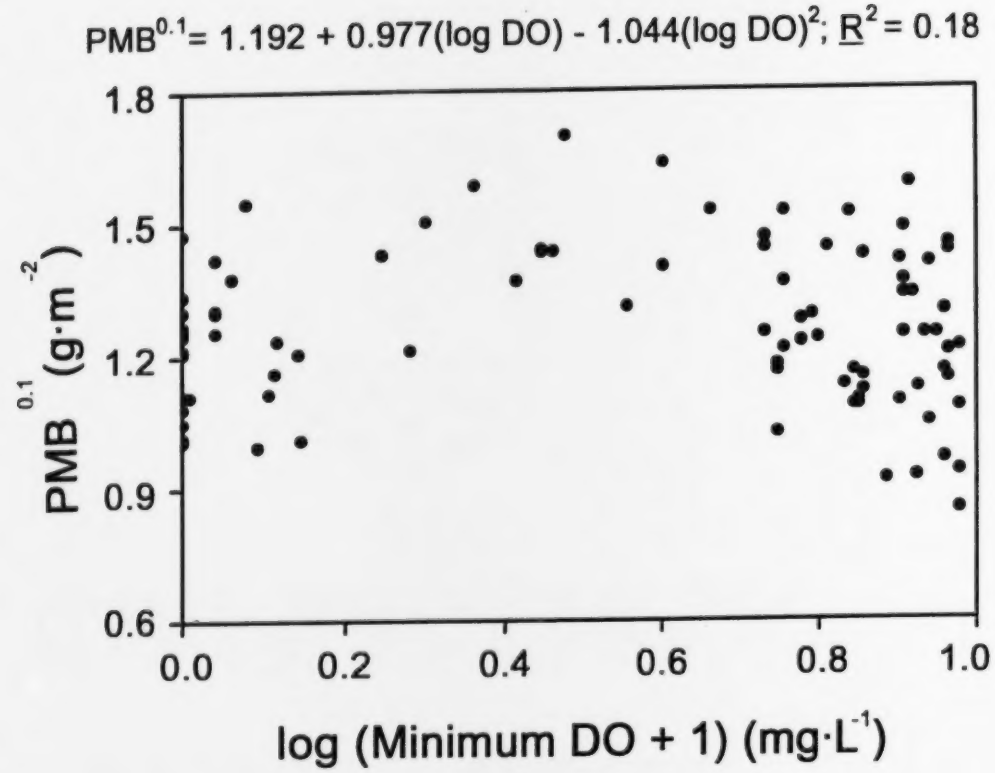

Figure 4.3. Relationship between profundal macroinvertebrate biomass (PMB, wet weight) and minimum dissolved oxygen (DO) concentration. All available data for Alberta lakes are included.

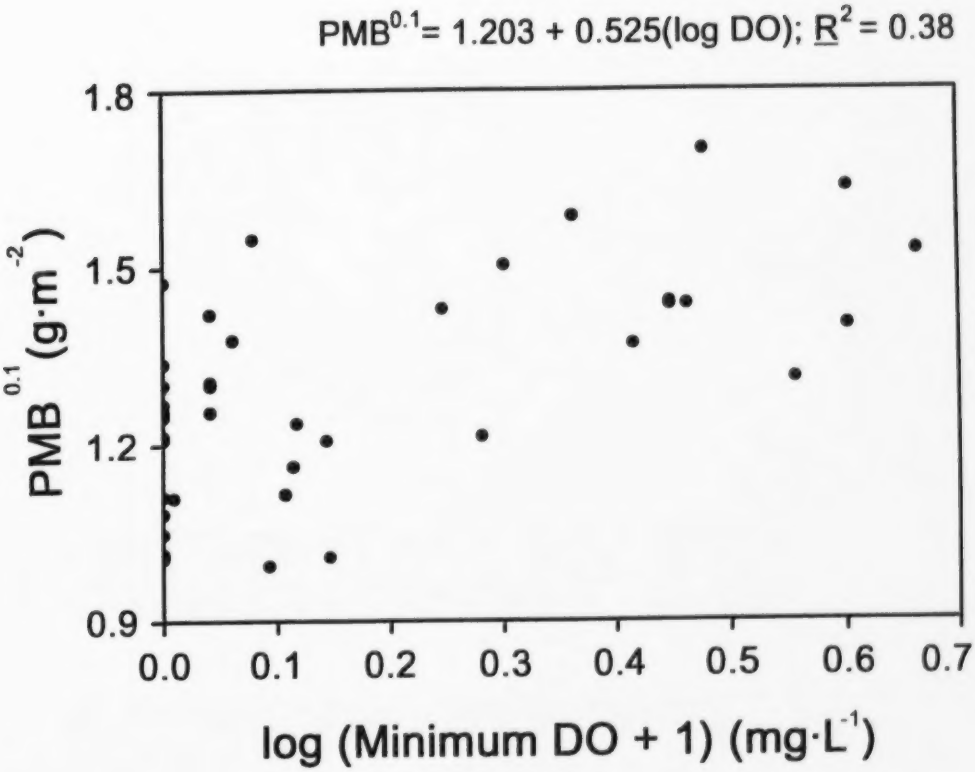

Figure 4.4. Relationship between profundal macroinvertebrate biomass (PMB, wet weight) and minimum dissolved oxygen (DO) concentration. Only PMB from sites in Alberta lakes where minimum DO was < 4 $mg \cdot L^{-1}$ were regressed.

4.5. References

Aston, R.J. 1973. Tubificids and water quality: a review. Environ. Pollut. 5: 1-10.

Berg, K., P.M. Jónasson, and K.W. Ockelmann. 1962. The respiration of some animals from the profundal zone of a lake. Hydrobiologia 19: 1-40.

Bidgood, B.J. 1972. Divergent growth in lake whitefish populations from two eutrophic Alberta Lakes. Ph.D. thesis. Univ. Alta., Edmonton.

Bishop, F.G. 1971. Limnology and fisheries of Sturgeon Lake, Alberta 1969-1970. Alta. Ld. For., Fish Wild. Div., Peace River.

Bishop, F.G. 1976. A comparative study of the limnology and fisheries of Snipe and Winagami lakes in northwestern Alberta. Alta. Rec. Parks Wild., Fish Wild. Div., Peace River.

Brinkhurst, R.O. 1974. The benthos of lakes. MacMillan Press, London.

Brundin, L. 1951. The relation of oxygen-microstratification at the mud surface to the ecology of the profundal bottom fauna. Inst. Freshwater Res. Drottningholm 32: 32-42.

Chambers, P.A., and E.E. Prepas. 1988. Underwater spectral attenuation and its effect on the maximum depth of angiosperm colonization. Can. J. Fish. Aquat. Sci. 45: 1010-1017.

Cornett, R.J., and F.H. Rigler. 1980. The areal hypolimnetic oxygen deficit: an empirical test of the model. Limnol. Oceanogr. 25: 672-679.

Cornett, R.J., and F.H. Rigler. 1987. Vertical transport of oxygen into the hypolimnion of lakes. Can. J. Fish. Aquat. Sci. 44: 852-858.

Cross, P.M. 1979. Limnological and fisheries surveys of the aquatic systems at Esso Resources Cold Lake base: Data volume. Aquat. Envir. Ltd., Calgary.

Curtis, P.J., and E.E. Prepas. 1993. Trends of dissolved organic carbon (DOC) from freshwater to saltwater. Verh. Internat. Verein. Limnol. 25: 298-301.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. J. Fish. Res. Board Can. 32: 2295-2332.

Dinsmore, W.P., and E.E. Prepas. In press. Impact of hypolimnetic oxygenation on profundal macroinvertebrates in a eutrophic lake in central Alberta. I. Changes in macroinvertbrate abundance and diversity. Can. J. Fish. Aquat. Sci.

Duarte, C., and J. Kalff. 1986. Littoral slope as a predictor of maximum biomass of submerged macrophyte communities. Limnol. Oceanogr. 31: 1072-1080.

English, W.G. 1979. Reesor Lake Reservoir: Lake survey inventory. Alta. Rec. Parks Wild., Fish Wild. Div. Unpubl. rep., Lethbridge.

English, W.G. 1985a. A limnological survey of McGregor Lake Reservoir. Alta. En. Nat. Resour., Fish Wild. Div., Lethbridge.

English, W.G. 1985b. A limnological survey of Newell Reservoir. Alta. En. Nat. Resour., Fish. Wild. Div., Edmonton.

Hanson, J.M., and R.H. Peters. 1984. Empirical prediction of crustacean zooplankton biomass and profundal macrobenthos biomass in lakes. Can. J. Fish. Aquat. Sci. 41: 439-445.

Heinis, F. 1993. Oxygen as a factor controlling occurrence and distribution of chironomid larvae. Ph.D. hesis, Universiteit van Amsterdam, The Netherlands.

Herreid, C.F. 1980. Hypoxia in invertebrates. Comp. Biochem. Physiol. 67: 311-320.

Johnson, R.K. 1984. Distribution of Chironomus plumosus and C. anthracinus with respect to sediment parameters in mesotrophic Lake Erken. Verh. Internat. Verein. Limnol. 22: 750-758.

Jónasson, P.M. 1978. Zoobenthos of lakes. Verh. Int. Verein. Limnol. 20: 13-37.

Kraft, M.E. 1977. Biological survey of Gull Lake, 1969. Alta. Rec. Parks Wild., Fish Wild. Div., Edmonton.

Lane, C.B. 1971. A survey of the fishery resources of Isle, Lac Ste. Anne and Matchayaw or Devils lakes, 1969. Alta. Ld. For., Fish Wild. Div. Unpubl. rep., Edmonton.

MacNeill, J.W. 1979. Beauvais Lake: Lake survey inventory. Alta. rec. Parks Wild., Fish Wild. Div. Unpubl. rep., Lethbridge.

Melack, J.M. 1983. Large, deep salt lakes: a comparative limnological analysis. Hydrobiologia 105: 223-230.

Miller, R.B. 1942. Biological survey of Sylan Lake, Alberta. Alta. Ld. Mines, Fish Game Admin., Edmonton.

Miller, R.B. 1955. Effect of Pocaterra power development on Lower Kananaskis Lake. Alta. Ld. For., Fish Wild. Div., Edmonton.

Miller, R.B., and W.H. Macdonald. 1950. Preliminary surveys of Alberta watersheds. vol. 1. 1947-1949. Govt. of Prov. Alta. Dept. Ld. For., Edmonton.

Miller, R.B., and M.J. Paetz. 1953. Preliminary surveys of Alberta watersheds. vol. 2. 1950-1952. Govt. of Prov. Alta. Dept. Ld. For., Edmonton.

Mitchell, P.A., and E.E. Prepas. 1990. Atlas of Alberta Lakes. Univ. Alberta Press, Edmonton, AB.

Nagell, B., and C.C. Landahl. 1978. Resistance to anoxia of Chironomus plumosus and Chironomus anthracinus (Diptera) larvae. Holarct. Ecol. 1: 333-336.

Nürnberg, G.K. 1987. A comparison of internal phosphorus loads in lakes with anoxic hypolimnia: laboratory incubations versus hypolimnetic phosphorus accumulation. Limnol. Oceanogr. 32: 1160-1164.

Pastorok, R.A., T.C. Ginn, and M.W. Lorenzen. 1980. Review of aeration/circulation for lake management. In Restoration of Lakes and Inland Waters. EPA 440/5-81-010. U.S. Envir. Prot. Ag., Washington D.C. 562 p.

Pinsent, M.E. 1967. A comparative limnological study of Lac la Biche and Beaver Lake, Alberta. M.Sc. thesis. Univ. Alta., Edmonton.

Prepas, E.E., and J.M. Burke. In press. Hypolimnetic oxygen injection as a method for improving water quality in lakes with large internal inputs of phosphorus. Can. J. Fish. Aquat. Sci.

Prepas, E.E., and D.O. Trew. 1983. Evaluation of the phosphorus-chlorophyll relationship for lakes off the Precambrian Shield in western Canada. Can. J. Fish. Aquat. Sci. 40: 27-35.

Rasmussen, J.B., and J. Kalff. 1987. Empirical models for zoobenthic biomass in lakes. Can. J. Fish. Aquat. Sci. 44: 990-1001.

Rawson, D.S. 1937. Biological examination of the Kananaskis Lakes, Alberta. Prep. for Alta. Ld. Mines, Fish Serv., Edmonton.

Robertson, M.R. 1970. Wolf Lake. Alta. Ld. For., Fish Wild. Div. Unpubl. rep., Edmonton.

Saether, O.A. 1979. Chironomid communities as water quality indicators. Holarct. Ecol. 2: 65-74.

Schroeder, D.G. 1974. Preliminary survey of Musreau Lake, July 1974. Alta. Ld. For., Fish Wild. Div. Unpubl. rep., Edmonton.

Smit, H., E. Dudock van Heel, and S. Wiersma. 1993. Biovolume as a tool in biomass determination of Oligochaeta and Chironomidae. Freshwater Biol. 29: 37-46.

Smith, V.H. 1979. Nutrient dependence of primary productivity in lakes. Limnol. Oceanog. 24: 1051-1064.

Strong, W.L., and K.R. Leggat. 1981. Ecoregions of Alberta. Alta. En. Nat. Resour., Resour. Eval. Plan. Div., Edmonton.

Takamura, K., and T. Iwakuma. 1990. Fate of macrozoobenthos in hypertrophic lakes: in situ rearing experiments with the larvae of Tokunagayusurika akamusi (Chironomidae). Arch. Hydrobiol. 119: 65-78.

Thompson, G.E. 1971a. The limnology and fishery management of Chestermere Lake, Alberta. Alta. Ld. For., Fish Wild. Div., Calgary.

Thompson, G.E. 1971b. The limnology and fishery management of Eagle Lake, Alberta. Alta. Ld. For., Fish Wild. Div., Edmonton.

Weisgerber, J. 1977. A preliminary report on the limnology of Lesser Slave Lake, Alberta. Alta. Rec. Parks Wild., Fish Wild. Div. Unpubl. rep., Edmonton.

Wiebe, A.P. 1975. A baseline biological inventory of some lakes in the Spray River watershed. Alta. Rec. Parks Wild., Fish Wild. Div., Calgary.

Williams, W.D., A.J. Boulton, and R.G. Taaffe. 1990. Salinity as a determinant of salt lake fauna: a question of scale. Hydrobiologia 197: 257-266.

5. General Discussion

Hypolimnetic oxygenation resulted in a significant increase in hypolimnetic dissolved oxygen (DO) concentrations in North Amisk from 1988 to 1991 inclusive, relative to South Amisk and South Baptiste and to pre-treatment years (Chapter 2). Although oxygen transfer occurred between North and South Amisk (Lawrence et al., In press), hypolimnetic DO concentrations remained lower in South Amisk relative to North Amisk throughout the study period. The duration of hypolimnetic anoxia (DO concentrations < 1 $mg \cdot L^{-1}$) in North Amisk was reduced considerably, from 4 mo during pre-treatment years to 3-6 wk during treatment. Hypolimnetic water temperatures also increased in North Amisk relative to pre-treatment years, but the magnitude of the increase was small compared to DO concentrations. Differences between pre-treatment and treatment temperatures were not statistically significant, except where modified by regional weather patterns. Thermal stratification in North Amisk was not disrupted by hypolimnetic oxygenation, as reported by other projects involving hypolimnetic aeration and destratification. Hypolimnetic water temperatures in South Amisk did not change appreciably compared to pre-treatment values and were lower relative to North Amisk over the entire treatment period. In South Baptiste, trends in hypolimnetic DO concentrations and temperatures remained similar between pre-treatment and treatment years.

Profundal (15-25 m) macroinvertebrate response to hypolimnetic oxygenation in North Amisk appeared limited primarily to Chironomus spp., which increased in abundance > 5-fold in both basins (Chapter 2). Numbers of Chironomus spp. at 25 m increased from 63% and 46% of the macroinvertebrate communities of North and South Amisk, respectively, in 1988 to 94% and 95%, respectively, in 1991 (Dinsmore and Prepas 1993). Oligochaete (Tubificidae) abundance may have increased in the shallow profundal region of North Amisk but remained very low in the deep profundal region. Unlike observations in other studies, numbers of Chaoborus spp. did not decline in either basin of Amisk Lake. The minor role of C. flavicans and C. punctipennis in Amisk Lake, in

contrast to the dominance of C. flavicans in Baptiste Lake, suggests differences in profundal conditions between the two lakes that are not understood at present. No discernable changes in other macroinvertebrate taxa were noted, and their numbers remained low throughout the study. The disproportionate increase in Chironomus spp. resulted in a decrease in profundal macroinvertebrate diversity over the treatment period, contrary to what was originally anticipated.

Chironomus response to hypolimnetic oxygenation depended on the species involved (Chapter 3). The greatest magnitude of response was observed for C. anthracinus. Mean densities and biomasses of C. anthracinus at 25 m increased 55- and 109-fold, respectively, in the treated basin, but major changes in abundance were not apparent until 2 yr after treatment commenced. Densities of C. anthracinus increased similarly in South Amisk, but mean larval weights and biomasses were significantly lower than in North Amisk ($P < 0.001$). The reduced anoxic period in North Amisk suggested that C. anthracinus had a longer period to feed and gain weight during the open-water season than was possible in South Amisk. Extended anoxic conditions, rather than low temperatures, appeared most important in limiting C. anthracinus distribution in the deep profundal regions of Amisk Lake. In contrast to C. anthracinus, densities and biomasses of C. cucini were higher in the reference basin of Amisk Lake. Densities of C. decorus and C. plumosus group increased in the treated north basin but remained of minor importance. In South Baptiste, densities of C. cucini and C. plumosus group declined over the study period. Although densities of profundal Chironomus spp. were initially similar in the three study basins, changes related to hypolimnetic oxygenation resulted in large increases in Amisk Lake that were not reflected in South Baptiste populations. Thus, it is unlikely that changes in Amisk Lake were part of a regional trend. Increased Chironomus spp. abundance in Amisk Lake suggested that a large potential food base for fish developed in the profundal region. However, its exploitation by the fish community may be hampered because a large proportion of the food base was located below 15 m, outside of preferred DO and temperature ranges for fish foraging (Aku et al., In press).

The taxonomy of the genus Chironomus is poorly understood at present (D.R. Oliver, Agriculture Canada, pers. comm.). Little is currently known of the biology of most Chironomus species, or their responses to gradients in DO and temperature. The results of this study suggest that multiple species of Chironomus are likely present in the profundal communities of other northern temperate lakes (e.g. Butler et al., In press). Also, this study underlines the importance of long-term data collection in Nearctic lakes to fully assess treatment impact on organisms that may take several years to respond. More research, in the form of controlled laboratory experiments, is necessary to determine how Chironomus species respond to gradients in DO concentrations and temperatures. A better understanding of how enhanced profundal macroinvertebrate communities contribute to nutrient dynamics is also desirable.

Although essential for supporting life, the role of DO as a limiting factor for profundal macroinvertebrate communities, particularly in eutrophic lakes, has never been empirically quantified. Multiple regression analyses of profundal macroinvertebrate biomass (PMB) and limnological data from 32 lakes of moderate to high primary productivity in Alberta indicated that minimum open-water DO concentrations explained 38% of the variance in PMB at sites where minimum DO was < 4 mg·L^{-1} (Chapter 4). This relationship was highly significant ($P < 0.001$), despite an average interval of 14 yr between PMB and DO data collection and large variations in PMB sampling protocol among the studies contributing data. Minimum DO concentrations accounted for no detectable variation when minimum DO was > 4 mg·L^{-1}. Bottom slope, as an indirect measurement of habitat quality (i.e. particle size) and detrital accumulation, explained 12% of variance in PMB. Specific conductivity contributed 4% of explained variation, for reasons not fully understood. These variables substantially increased the amount of variance explained for PMB collected at sites where minimum DO was < 4 mg·L^{-1}, explaining a total of 55% of the variance in PMB. Variables indicative of phytoplankton biomass (chlorophyll a, total phosphorus, and Secchi transparency) were nonsignificant predictors of PMB in these predominantly eutrophic lakes, in contrast to the results of Hanson and Peters (1984) and Rasmussen and Kalff (1987), who studied predominantly

oligotrophic systems. Other variables such as water temperature and anoxic period had no detectable relationship with PMB, suggesting that variation in these parameters was low among the lakes in this study. The results of this study suggest that DO concentrations < 4 $mg \cdot L^{-1}$ are limiting to profundal macroinvertebrate communities in eutrophic lakes. Better estimates of PMB and DO measured concurrently should improve the predictive power of future models.

Profundal macroinvertebrate response to hypolimnetic oxygenation in Amisk Lake differed markedly from results reported by previous aeration studies. Only Chironomus spp. and to a lesser extent tubificid oligochaetes responded favourably to treatment. Amisk Lake is larger and deeper than other treated lakes, so it was not feasible to elevate hypolimnetic DO concentrations to levels achieved by these other studies. Also, the profundal habitat of Amisk Lake offered limited choices for potential colonizers from shallower depths, especially non-detritivorous taxa. However, despite the small increase in hypolimnetic DO concentrations relative to treatment programs carried out in other lakes, Chironomus spp. responded positively to hypolimnetic oxygenation in Amisk Lake. The main goal of the Amisk Lake project was to improve fisheries habitat (Prepas et al., In press); by establishing a large potential food source, hypolimnetic oxygenation appears to have satisfied one of the criteria necessary to achieve that goal.

5.1. References

Aku, P.M.K., L.G. Rudstam, and W.M. Tonn. In press. Impact of hypolimnetic oxygenation on the vertical distribution of cisco (Coregonus artedi) in Amisk Lake, Alberta. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Butler, M.G., I.I. Kiknadze, J.K. Cooper, and M. Siirin. In press. Cytologically identified Chironomus species from lakes in North Dakota and Minnesota, USA. In P. Cranston [ed.] Chironomids: from genes to ecosystems. Proceedings of the 12th International Symposium on Chironomidae. CSIRO Publ. Melbourne.

Dinsmore, W.P., and E.E. Prepas. 1993. Changes in macroinvertebrate diversity in a deep eutrophic lake undergoing hypolimnetic oxygen injection, with particular reference to Chironomus spp. (Chironomidae). Verh. Internat. Verein. Limnol. 25: 302-306.

Hanson, J.M. and R.H. Peters. 1984. Empirical predictions of crustacean zooplankton and profundal macrobenthos biomass in lakes. Can. J. Fish. Aquat. Sci. 41: 439-445.

Lawrence, G.A., J.M. Burke, T.P. Murphy, and E.E. Prepas. In press. Exchange flows between the two basins of Amisk Lake. Can. J. Fish. Aquat. Sci. 53: 0000-0000.

Prepas, E.E., K.M. Field, T.P. Murphy, W.L. Johnson, and W.M. Tonn. In press. Introduction to the Amisk Lake project: oxygenation of a deep eutrophic lake. Can. J. Fish. Aquat. Sci. 53:0000-0000.

Rasmussen, J.B., and J. Kalff. 1987. Empirical models for zoobenthic biomass in lakes. Can. J. Fish. Aquat. Sci. 44: 990-1001.

Appendix A: Hypolimnetic volume-weighted dissolved oxygen concentrations and water temperatures for North and South Amisk and South Baptiste, 1980-1991.

Table 1. Hypolimnetic volume-weighted dissolved oxygen concentrations and water temperatures of 15- (12-18 m), 20- (17-23 m) and 25-m (22-28 m) strata, measured during the open-water season (May-November) for the north basin of Amisk Lake, 1980-1991. No data were collected during 1983 and 1986. Blanks indicate no data.

		Dissolved Oxygen ($mg \cdot L^{-1}$)			Temperature (°C)		
Year	Date	Stratum			Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1980	14 May	3.7	3.4	3.2	6.0	5.7	5.6
	28 May	2.6	1.9	1.5	6.5	6.0	5.9
	11 June	1.4	0.8	0.5	6.7	6.4	6.4
	2 July	0.7	0.2	0.1	7.3	6.8	6.6
	22 July	0.0	0.0	0.0			
	12 August				7.7	7.1	7.0
1981	15 June	1.9	1.6	1.3	6.3	6.1	5.9
	13 July	0.3	0.1	0.1	7.1	6.7	6.5
	10 August	0.2	0.1	0.1	7.5	6.9	6.6
1982	17 May				4.5	4.2	4.1
	7 June	4.2	3.3	3.3	5.9	5.2	5.1
	28 July	2.3	1.4	0.9	6.3	5.8	5.6
	19 July	0.6	0.1	0.1	6.1	5.7	5.5
	9 August	0.1	0.1	0.0	6.4	6.0	5.8
	31 August	0.1	0.1	0.0	6.8	6.3	6.1
1984	8 May				5.7	5.2	5.0
	15 May				6.2	5.8	5.6
	23 May				6.2	5.7	5.6
	30 May	6.7	4.7	4.1	6.7	5.9	5.8
	6 June				7.3	6.1	5.9
	12 June	5.3	3.0	2.3	7.5	6.3	6.2
	21 June				7.9	6.6	6.4
	26 June	3.8	1.5	0.4	8.0	6.9	6.6
	5 July				8.1	7.1	6.9
	10 July	1.9	0.5	0.2	8.1	7.2	7.0
	16 July				8.3	7.1	7.0
	24 July	0.9	0.2	0.1	8.2	7.2	7.1
	31 July				8.3	7.3	7.1
	8 August	0.0	0.0	0.0	8.5	7.5	7.2
	14 August				8.5	7.5	7.3
	21 August	0.0	0.0	0.0	8.3	7.5	7.4
	28 August				8.3	7.4	7.2
1985	20 May				4.5	4.3	4.1
	7 June	1.3	0.8	0.6	5.3	4.8	4.7
	21 June				5.7	5.1	4.9
	1 July	0.9	0.6	0.3	6.0	5.5	5.3

Table 1 (cont.)

Year	Date	Dissolved Oxygen ($mg \cdot L^{-1}$) Stratum			Temperature (°C) Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1985	9 July				6.4	5.7	5.5
	21 July	0.6	0.4	0.2	6.4	5.8	5.6
	31 July				6.6	5.9	5.7
	12 August	0.3	0.2	0.1	7.0	6.2	6.0
1987	18 May	5.6	2.8	1.7	5.3	4.9	4.8
	25 May	4.6	2.5	1.7	6.5	5.6	5.4
	1 June				6.5	5.8	5.6
	8 June	3.3	1.5	0.8	6.8	6.1	5.8
	17 June	1.5	0.7	0.4	7.0	6.5	6.4
	22 June	0.9	0.2	0.0	6.9	6.5	6.4
	29 June	0.8	0.2	0.0	7.3	6.6	6.5
	7 July	0.5	0.3	0.0	7.4	6.7	6.5
	13 July	0.2	0.0	0.0	7.8	6.9	6.7
	20 July	0.1	0.0	0.0	7.6	7.0	6.8
	27 July	0.0	0.0	0.0	7.6	7.0	6.9
	4 August	0.1	0.0	0.0	7.9	7.3	7.1
	9 August	0.1	0.0	0.0	7.9	7.3	7.0
	13 August	0.4	0.0	0.0	7.9	7.3	7.2
1988	18 May				5.9	5.5	5.4
	24 May	4.9	3.7	2.4	6.4	6.0	5.8
	29 May				6.3	6.0	5.8
	10 June	4.4	3.5	2.4	6.8	6.6	6.4
	15 June	4.2	3.3	2.4	7.3	6.7	6.5
	20 June	3.3	2.5	2.0	7.4	7.0	6.8
	27 June	3.5	2.9	2.1	7.5	7.2	7.1
	4 July	2.3	2.0	1.8	7.8	7.4	7.3
	11 July	3.0	2.0	1.6	8.1	7.8	7.6
	17 July	2.0	2.2	1.7			
	25 July	2.4	1.7	1.5			
	1 August	1.0	1.0	0.9	8.8	8.4	8.2
	7 August	1.6	1.5	1.1			
	15 August	0.6	0.5	0.4			
	22 August	0.8	0.8	0.6	9.2	8.9	8.7
	29 August				9.4	9.1	9.0
	6 September				9.3	9.1	9.0
	12 September	3.4	0.9	0.5	9.6	9.4	9.3
	19 September	3.0	0.6	0.2	9.8	9.5	9.4
	26 September	4.0	1.1	1.1	10.0	9.7	9.6
	2 October	4.9	2.8	1.7	10.2	10.0	9.9
	18 October	8.2	8.2	8.2	10.0	9.9	9.5
	31 October	9.1	9.0	8.8	6.5	6.5	6.5

Table 1 (cont.)

Year	Date	Dissolved Oxygen ($mg \cdot L^{-1}$) Stratum			Temperature (°C) Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1989	9 May	9.1	9.0	9.1	5.0	4.9	4.8
	17 May	7.8	7.5	7.0	5.7	5.5	5.4
	21 May	7.3	6.8	6.0	6.3	6 0	5.8
	30 May	8.1	6.7	6.5	6.9	6.5	6.3
	6 June				7.2	6.6	6.5
	16 June	5.5	4.8	4.2	7.4	7.0	6.9
	20 June				7.6	7.3	7.0
	29 June	4.9	3.6	2.7	7.7	7.3	7.2
	4 July	4.3	3.0	2.0	8.2	7.5	7.3
	11 July	4.9	3.5	2.2			
	18 July	3.9	2.7	2.0	8.4	8.1	7.9
	25 July				8.6	8.3	8.1
	31 July				8.7	8.4	8.3
	2 August	3.9	3.1	2.0			
	9 August	2.5	1.9	1.5	9.5	9.1	8.8
	15 August	2.2	2.2	1.7	9.2	8.9	8.7
	22 August	2.2	2.0	1.5	9.5	9.3	9.2
	29 August	2.6	2.4	1.3			
	7 September	1.7	1.6	1.3	10.1	9.5	9.1
	20 September	4.2	1.9	0.9	10.4	10.0	9.5
	2 October	4.3	2.1	1.4	10.6	9.9	9.7
	16 October	8.3	8.4	8.6			
	18 October				8.3	8.2	8.2
	2 November				5.6	5.6	5.5
1990	8 May	9.2	9.1	9.1	5.6	5.5	5.5
	14 May	8.2	7.8	7.4	5.6	5.4	5.3
	24 May	8.6	7.7	7.4	6.2	5.9	5.7
	28 May	8.9	8.2	7.7	7.4	6.7	6.4
	4 June	7.7	7.1	6.8			
	10 June	8.6	8.2	7.3	8.3	7.9	7.8
	18 June	7.9	7.5	6.7	9.1	8.6	8.3
	24 June	7.0	6.7	6.3	9.7	9.3	9.0
	2 July	6.4	5.8	5.4	10.0	9.8	9.6
	8 July	5.8	5.3	4.8	10.2	10.0	10.0
	16 July	5.2	4.8	4.5	10.6	10.1	10.0
	21 July	4.9	4.1	3.8	11.1	10.6	10.2
	30 July	3.6	3.3	3.0	11.6	11.0	10.6
	3 August	3.5	2.8	2.4	11.5	10.9	10.6
	14 August	1.8	1.9	1.7	11.3	10.8	10.5
	20 August	1.8	1.9	1.6	11.7	11.3	11.0
	28 August	2.5	1.8	0.8	12.0	11.5	11.2
	10 September	3.0	0.8	0.3	13.2	12.6	12.3

Table 1 (concl.)

Year	Date	Dissolved Oxygen ($mg \cdot L^{-1}$) Stratum			Temperature (°C) Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1990	25 September	4.0	2.0	0.7	14.0	13.5	13.2
	9 October	6.9	7.0	7.0	11.1	11.0	11.0
	5 November	9.5	9.2	9.1	5.0	5.0	5.0
1991	14 May	9.0	8.6	8.2	4.5	4.4	4.3
	19 May	7.4	7.5	7.5	4.7	4.6	4.6
	27 May	7.0	6.5	6.2	5.3	4.8	4.7
	3 June	6.6	6.0	5.6	6.3	5.5	5.3
	10 June	6.1	5.2	4.8	6.5	6.0	5.7
	17 June	5.7	4.6	3.9	6.9	6.2	6.0
	24 June	4.6	4.3	3.8	7.5	6.8	6.6
	30 June	4.5	3.8	3.2	7.8	7.3	7.1
	8 June	4.0	3.6	3.1	7.8	7.4	7.1
	14 July	3.5	2.8	2.5	7.9	7.3	7.0
	22 July	2.9	2.4	1.9			
	28 July	2.9	2.2	1.7	8.1	7.6	7.4
	5 August	2.6	2.1	1.6	8.9	8.3	8.1
	11 August	2.4	2.0	1.7	8.9	8.4	8.2
	19 August	2.1	1.7	1.5	9.3	8.3	7.6
	25 August	2.5	1.9	1.2	9.2	8.8	8.6
	2 September	2.5	1.4	1.1	9.6	9.2	9.0
	16 September	1.5	1.1	0.8	10.4	9.9	9.6
	30 September	4.9	2.3	1.0	10.9	10.5	10.3
	16 October	9.5	9.0	8.6	9.4	9.4	9.4
	29 October	10.3	10.4	10.3	4.7	4.7	4.6

Table 2. Hypolimnetic volume-weighted dissolved oxygen concentrations and water temperatures of 15- (12-18 m), 20- (17-23 m) and 25-m (22-28 m) strata, measured during the open-water season (May-November) for the south basin of Amisk Lake, 1980-1991. No data were collected from 1983 to 1986 inclusive. Blanks indicate no data.

		Dissolved Oxygen ($mg \cdot L^{-1}$)			Temperature (°C)		
Year	Date	Stratum			Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1980	14 May	3.6	2.5	1.9	5.8	5.2	4.8
	28 May	2.6	2.0	1.3	6.2	5.5	5.0
	11 June	2.2	1.2	0.5	6.7	5.5	5.0
	2 July	1.6	0.6	0.1	7.1	6.0	5.2
	22 July	0.0	0.0	0.0			
	12 August				7.5	6.1	5.2
1981	15 June	4.0	2.8	1.9	6.6	5.5	4.8
	13 July	1.8	0.9	0.3	7.0	5.7	5.0
	10 August	0.0	0.0	0.0	7.2	6.0	5.2
1982	17 May	4.5	3.6	3.1	4.2	3.9	3.7
	7 June	4.8	3.2	2.0	6.1	4.7	4.1
	28 June	3.6	2.4	1.3	6.2	5.0	4.4
	19 July	2.0	1.2	0.5	6.3	5.0	4.3
	9 August	0.4	0.2	0.0	6.3	5.2	4.4
	31 August	0.1	0.1	0.1	6.8	5.3	4.5
1987	18 May	4.0	2.7	1.5	5.2	4.3	3.9
	25 May	4.4	2.1	1.4	6.6	4.3	3.7
	8 June	3.3	2.3	1.3	6.9	5.4	4.5
	17 June	2.6	1.6	0.9	7.2	5.8	5.0
	22 June	2.7	1.9	1.1	7.2	5.8	4.7
	29 June	1.8	1.4	0.8	7.4	5.8	5.0
	7 July	1.4	0.6	0.0	7.4	5.7	4.9
	13 July	0.8	0.3	0.0	7.5	5.4	4.9
	20 July	0.4	0.0	0.0	7.7	5.8	4.9
	27 July	0.2	0.0	0.0	7.6	5.8	5.0
	4 August	0.1	0.0	0.0	7.9	6.2	5.2
	9 August	0.2	0.0	0.0	8.0	6.0	5.0
	13 August	0.2	0.0	0.0	7.8	6.2	5.1
1988	16 May				5.8	4.9	4.3
	24 May	4.5	2.7	1.0	6.0	5.1	4.7
	29 May				6.0	4.9	4.5
	10 June	2.9	1.2	0.6	5.9	4.8	4.5
	15 June	2.6	0.8	0.4	6.4	4.8	4.5
	20 June	2.6	1.1	0.4	6.9	5.5	4.8
	27 June	2.7	1.4	0.5	7.2	5.9	5.0
	4 July	2.5	1.2	0.5	7.1	5.5	4.8

Table 2 (cont.)

Year	Date	Dissolved Oxygen ($mg \cdot L^{-1}$) Stratum			Temperature (°C) Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1988	11 July	1.3	0.9	0.5	7.2	5.6	4.9
	17 July	1.2	0.9	0.5			
	18 July				7.6	5.6	4.8
	25 July	0.6	0.5	0.4	7.3	5.5	4.9
	1 August	0.5	0.5	0.4	7.4	5.6	4.9
	7 August	1.0	0.8	0.5	7.7	5.8	5.0
	15 August	0.5	0.4	0.3	7.4	5.4	4.9
	22 August	0.4	0.3	0.1	7.7	5.7	4.9
	29 August				7.5	5.2	4.8
	12 September	2.6	0.3	0.1	8.4	5.7	5.0
	19 September	2.2	0.1	0.0	8.0	5.5	5.0
	25 September	3.5	0.5	0.0	8.0	5.5	4.9
	2 October	3.3	0.6	0.1	8.9	5.7	4.9
	18 October	3.5	0.5	0.3	8.1	5.6	4.9
	31 October	5.6	3.2	1.4	6.3	6.2	6.1
	8 May				4.3	4.1	3.9
1989	9 May	5.0	4.0	1.7			
	17 May	6.0	4.9	3.9	5.6	4.9	4.5
	23 May	6.8	5.6	3.8	6.1	5.5	5.0
	30 May	8.5	6.0	3.8	7.5	5.9	5.2
	6 June				6.7	5.6	5.0
	16 June				7.2	5.8	5.1
	18 June	4.5	3.1	2.2			
	20 June				7.3	6.2	5.3
	28 June				7.4	6.0	5.2
	29 June	4.0	2.3	1.3			
	4 July	3.8	2.0	0.8	7.4	6.1	5.3
	11 July	3.3	1.4	0.5			
	18 July	3.3	1.2	0.0	7.8	6.2	5.3
	25 July				8.1	6.3	5.5
	31 July				8.0	6.3	5.2
	2 August	1.3	0.1	0.0			
	9 August	0.9	0.0	0.0	8.9	7.1	6.2
	15 August	1.5	0.5	0.0	8.9	7.2	6.2
	22 August	1.2	0.3	0.0	8.6	6.9	6.1
	29 August	1.1	0.4	0.0			
	5 September	0.8	0.5	0.5	9.0	7.1	6.2
	18 September	3.5	0.7	0.5	9.1	6.8	6.0
	2 October	3.3	0.5	0.5	9.3	6.8	5.5
	16 October	8.2	3.9	0.5	8.2	6.8	5.4
	2 November	7.5	7.4	7.2	5.7	5.6	5.6

Table 2 (concl.)

Year	Date	Dissolved Oxygen ($mg \cdot L^{-1}$) Stratum			Temperature (°C) Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1990	8 May	8.3	8.2	7.6	5.4	5.2	5.0
	14 May	8.2	7.6	7.1	5.7	5.4	5.2
	24 May	7.6	6.5	5.8	6.8	5.9	5.3
	28 May	7.8	7.0	6.2	6.6	5.8	5.3
	4 June	7.0	6.1	5.6	6.9	5.7	5.3
	10 June	7.3	6.3	5.6	7.1	6.0	5.5
	18 June	6.9	5.5	4.6	8.4	6.5	5.7
	24 June	6.3	5.2	4.1	8.2	6.4	5.7
	2 July	5.4	4.4	3.3	8.5	6.6	5.9
	8 July	5.3	4.5	3.2	10.4	8.5	7.6
	16 July	4.7	4.2	2.7	9.3	6.9	5.9
	21 July	4.2	3.7	2.7	9.6	7.3	6.2
	30 July	3.2	3.1	2.3	9.5	7.3	6.1
	3 August	2.9	2.6	1.5	9.5	6.9	5.8
	14 August	2.2	2.1	1.3	9.7	7.3	6.1
	20 August	1.4	1.6	0.7	9.8	7.3	6.1
	28 August	1.1	1.3	0.4	9.8	7.1	5.9
	10 September	0.5	0.6	0.3	9.8	7.0	6.1
	25 September	0.5	0.1	0.0	10.9	7.2	6.2
	9 October	6.0	1.5	0.1	10.2	7.8	6.2
	5 November	6.9	6.9	7.0	5.4	5.4	5.4
1991	14 may	8.6	6.3	4.9	4.4	3.7	3.4
	19 May	8.3	7.2	5.3	5.0	4.3	3.7
	27 May	7.3	6.0	4.7	4.8	4.0	3.7
	3 June	6.2	5.3	3.9	5.0	4.2	3.9
	10 June	6.0	5.1	3.7	5.5	4.7	4.0
	17 June	5.0	4.0	2.6	5.8	4.7	4.1
	24 June	4.6	3.3	2.0	5.9	4.3	4.0
	30 June	3.8	3.2	1.7	6.6	5.0	4.4
	8 June	3.2	2.6	1.5	6.7	5.0	4.2
	14 June	2.7	2.4	1.5	6.6	4.7	4.0
	22 June	2.2	1.8	0.7			
	28 June	2.1	1.5	0.6	7.2	4.8	4.0
	5 August	1.3	1.3	0.4	7.1	4.8	4.1
	11 August	1.4	1.1	0.5	7.8	5.5	4.4
	19 August	0.9	0.6	0.4	7.5	4.9	4.0
	25 August	1.2	0.7	0.3	7.6	5.0	4.1
	2 September	0.7	0.5	0.4	7.6	5.4	4.4
	16 September	0.5	0.2	0.2	8.2	5.2	4.3
	30 September	2.6	0.3	0.1	8.8	5.4	4.4
	16 October	8.6	3.2	0.3	9.1	7.8	5.4
	29 October	8.5	8.5	7.6	5.0	5.0	4.9

Table 3. Hypolimnetic volume-weighted dissolved oxygen concentrations and water temperatures of 15- (12-18 m), 20- (17-23 m) and 25-m (22-25 m) strata, measured during the open-water season (May-November) for the south basin of Baptiste Lake, 1980-1991. Blanks indicate no data.

		Dissolved Oxygen ($mg \cdot L^{-1}$)			Temperature (°C)		
Year	Date	Stratum			Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1980	13 May	2.3	0.4	0.3	6.4	6.0	5.9
	27 May	1.0	0.1	0.1	6.6	6.1	6.1
	10 June	0.1	0.0	0.0	6.8	6.3	6.2
	3 July	0.0	0.0	0.0	6.8	6.5	6.4
	13 August				7.4	6.7	6.5
1981	16 June	1.8	0.4	0.0	6.9	6.2	6.0
	14 July	0.3	0.2	0.0	6.8	6.2	5.9
	11 August	0.1	0.0	0.0	6.6	6.2	6.2
1982	18 May	6.5	1.9	0.0	4.5	4.0	3.6
	8 June	3.1	1.7	0.4	6.1	5.6	5.4
	29 June	0.6	0.3	0.2	6.0	5.5	5.4
	20 July	0.1	0.0	0.0	6.0	5.4	5.3
	10 August	0.0	0.0	0.0	6.1	5.5	5.4
	31 August	0.0	0.0	0.0	6.3	5.7	5.5
1983	11 May	6.5	5.7	4.4	5.2	5.0	5.0
	9 June	7.7	6.5	5.1	6.8	6.2	6.1
	7 July	1.2	0.9	0.8	7.0	6.4	6.0
	4 August	2.7	0.8	0.3	7.5	6.2	6.0
1984	3 May	10.6	9.6	8.7	6.5	6.1	5.9
	29 May	6.6	5.4	4.4	7.7	7.2	7.1
	28 June	2.9	0.9	0.0	9.9	9.4	9.1
	24 July	0.0	0.0	0.0	10.0	9.4	9.2
	21 August	0.0	0.0	0.0	10.0	9.4	9.2
1985	16 May	7.4	6.7	5.4	6.4	6.0	5.6
	4 June	4.8	3.0	2.1	6.8	6.0	5.9
	4 July	0.4	0.0	0.0	7.2	6.2	6.0
	1 August	0.0	0.0	0.0	7.4	6.6	6.4
	28 August	0.0	0.0	0.0	7.7	6.8	6.6
1986	5 June	2.7	1.9	1.0	6.6	6.2	6.1
	3 July	0.3	0.0	0.0	7.4	6.7	6.4
	7 August	0.0	0.0	0.0	7.2	6.6	6.5
	28 August	0.1	0.0	0.0	7.7	6.6	6.5

Table 3 (concl.)

Year	Date	Dissolved Oxygen ($mg \cdot L^{-1}$) Stratum			Temperature (°C) Stratum		
		15 m	20 m	25 m	15 m	20 m	25 m
1987	6 May	3.8	2.2	0.4	4.6	4.3	3.9
	3 June	2.9	1.7	1.3	6.3	5.4	5.2
	2 July	0.0	0.0	0.0	7.2	6.4	6.0
	29 July	0.0	0.0	0.0	7.9	6.6	6.3
1988	25 May	1.8	0.1	0.0	5.8	4.8	4.5
	14 June	0.3	0.0	0.0	6.3	5.0	4.7
	12 July	0.0	0.0	0.0	7.4	5.7	5.8
	9 August	0.0	0.0	0.0	7.2	5.8	5.4
	11 September	2.4	0.6	0.6	8.6	5.5	5.1
	9 October	1.9	0.5	0.4	7.5	6.0	5.3
	5 November	7.4	7.3	7.3	4.6	4.6	4.6
1989	24 May	4.5	2.8	2.2	6.8	5.9	5.8
	22 June	1.1	0.3	0.0	7.1	6.7	6.5
	20 July	0.0	0.0	0.0	7.6	7.0	6.8
	15 August	0.0	0.0	0.0	7.7	7.2	7.0
	10 September	0.0	0.0	0.0	7.7	7.0	7.0
	4 October	0.3	0.0	0.0	7.6	6.9	6.8
	3 November	7.8	7.8	7.8	5.4	5.4	5.4
1990	9 May	7.1	6.5	6.0	5.2	5.0	4.9
	7 June	3.4	2.3	2.1	6.2	5.8	5.7
	28 June	1.5	0.2	0.1	6.6	5.9	5.7
	26 July	0.2	0.1	0.1	6.9	6.0	5.7
	22 August	0.0	0.0	0.0	6.7	5.9	5.6
	26 September	0.1	0.0	0.0	6.5	5.7	5.5
	23 October	6.7	6.6	6.7	6.0	6.2	6.1
1991	15 May	2.8	0.5	0.7	4.7	4.2	4.2
	26 May	2.6	1.0	0.6	4.4	4.1	4.0
	9 June	0.8	0.3	0.3	4.6	4.2	4.1
	22 June	0.7	0.2	0.1	5.5	4.4	4.1
	6 July	0.1	0.0	0.0	4.7	4.2	4.2
	22 July	0.2	0.0	0.0	5.1	4.4	4.4
	4 August	0.1	0.0	0.0	5.4	4.8	4.7
	17 August	0.1	0.0	0.0	5.7	4.7	4.6
	17 September	2.2	0.0	0.0	6.5	5.0	4.8
	1 October	2.4	0.0	0.0	6.4	5.0	4.8
	30 October	8.6	8.6	9.0	4.1	4.0	3.9

Appendix B: Macroinvertebrate counts per grab collected from North and South Amisk and South Baptiste, 1988-1991.

List of Macroinvertebrate Taxa Abbreviations used in Tables 1 - 3

ABL Ablabesmyia spp.

ANT Chironomus anthracinus

CER Ceratopogonidae

CHI other chironomid genera

COL Coleoptera

CU1 Chironomus cucini (no tubuli)

CU2 Chironomus cucini (with tubuli)

DEC Chironomus decorus

EPH Ephemeroptera

FLA Chaoborus flavicans

FPU Chaoborus flavicans pupae

GAM Gammarus lacustris

GAS Gastropoda

HCA Hydracarina

HIR Hirudinea

HYA Hyalella azteca

HYD Hydra spp.

IMM Chironomus spp. early instars

NEM Nematoda (Mermithidae)

OLI Oligochaeta

PLU Chironomus plumosus group

PRO Procladius spp.

PUN Chaoborus punctipennis

PUP Chironomus spp. pupae

SPH Sphaeriidae

TAN Tanytarsus spp.

TRI Trichoptera

Table 1a. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20-, 25- and 30-m depths (± 2.5 m) along Transects A1, A2 and A3 in the north basin of Amisk Lake (North Amisk) during 1988. Blanks indicate zero counts.

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
16 May	A1	15	A1E1511	1	9	1			2								4										
			A1E1521		4			1	1							1	2				1						
			A1E1531	1	2			2	3																		
			A1W1511		34						1						9										
			A1W1521		55				1								12				2						
		20	A1E2011		2			1								1										
			A1E2021		2							1		19	1							1					
			A1W2011		6										1	1											
			A1W2021		7											1											
16 May	A2	15	A2E1511	4	1				3								4										
			A2E1521	5	4				8								30										
			A2W1511		4				5		2						9				1					1	
			A2W1521		6				7							1	6										
		20	A2E2011		1						1																
			A2E2021																								
			A2W2011		5				6		1						5										
			A2W2021		4				2																		
		25	A2E2511		1	1			1		1				1												
			A2E2521																	2							
			A2W2511			1										3											
			A2W2521													1											
		30	A2E3011																								
			A2E3021		1																						
16 May	A3	15	A3E1511		3										1	1											
			A3E1521			1					1				1	2											
			A3W1511	1	4			1	2	1						1	16										
			A3W1521							7							7										
		20	A3E2011		3										1	1											
			A3E2021		1											1	2										
			A3W2011		4						1																
			A3W2021		8																						

Table 1a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
10 June	A1	15	A1E1511		7										1		4				1						
			A1W1511	2	14						2			1			21										
			A1W1521		32										3		5				1						
10 June	A2	15	A2E1511														15										
			A2E1521	1	6						1			1			3										
			A2W1511	1	3						1					1	6										
			A2W1521	1	6											2	8							1			
		20	A2E2011		4						1				1	1											
			A2E2021		1			1									1										
			A2W2011		3										1	1											
			A2W2021		7																						
		25	A2E2511		1										1												
			A2E2521																								
			A2W2511		1						1																
			A2W2521								1																
		30	A2E3011																								
			A2E3021																								
			A2W3011																								
			A2W3021		1																				1		
13 June	A3	15	A3E1511							1	5					1											
			A3E1521		1						1				1	1											
			A3W1511	1	10							1		1			21										1
			A3W1521	2	4					1							15										
		20	A3E2011		4																		1				
			A3E2021		2																						
			A3W2011														1										
			A3W2021		7							1											1				

Table 1a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
23 June	A1	15	A1E1511		3												1										
			A1E1521		4	1											12										
			A1W1511		1						1						3				1						
			A1W1521		12						1						11						1	1			
		20	A1E2011		4										1										1		
			A1E2021		5																						
			A1W2011		2																						
			A1W2021		7						1				1												
24 June	A2	15	A2E1511	2	1						1			1	2		17				1		1				
			A2E1521	2	4	1					4	1		2			32										1
			A2W1511	1	8						2	1		3			4										
			A2W1521	1	3						2			1		1	7										
		20	A2E2011		1	2					2						1										
			A2E2021			2					1				1	1	1										
			A2W2011		4										1	2	1										
			A2W2021		4			1								2	1										
		25	A2E2511		2	1																					
			A2E2521								2																
			A2W2511		3																						
			A2W2521		1										1												
		30	A2E3011								3																
			A2E3021								2																
			A2W3011																	1	1						
			A2W3021		1						2											2					
25 June	A3	15	A3E1511		1					3	3			1													
			A3E1521		3					2	3	1	1	2			24										
			A3W1511	1	5												4										
			A3W1521		5	2											4										
		20	A3E2011		1																						
			A3E2021		5	2					1				1												

Table 1a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
5 July	A1	15	A1E1511		4	2				1							2			1							
			A1E1521		2	1				1							8										
			A1W1511		8	2		2		5							3				1						
			A1W1521		7	1				1	3			1			3										
		20	A1E2011		4						1					1					1						
			A1E2021		5						1																
			A1W2011		2						1				1												
			A1W2021								1				1												
5 July	A2	15	A2E1511	1	2					10	3	1					7			1							
			A2E1521		2	1				14	1			1	1		7										
			A2W1511		4	2				1	1						6							1			
			A2W1521		8					1						2	8										1
		20	A2E2011		1					2	2						1										
			A2E2021		2					1																	
			A2W2011		5	1				2	2						1										
			A2W2021		3																						
		25	A2E2511		2	1					3			1													
			A2E2521	1	1																						
			A2W2511		2					1																	
			A2W2521																								
		30	A2E3011		2																						
			A2E3021		3						2		1	1													
			A2W3011		1																						
			A2W3021		2																						
10 July	A3	15	A3E1511							3	11																
			A3E1521		6					16							21										1
			A3W1511	1						6	4	1		1		1											
			A3W1521		9			1		29		1					26										
		20	A3E2011							1	1										1						
			A3E2021							1	3							1		1							

Table 1a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
20 July	A1	15	A1E1511	6	1	1						1				1											
			A1E1521		1	2										1	5										
			A1W1511		6											1								1			
			A1W1521		7			1		10	1			1			7										
		20	A1E2011		1						1				1												
			A1E2021		1																						
			A1W2011		5	1					5																
			A1W2021		5					2	1																
21 July	A2	15	A2E1511	1	3					17	1			1			8										
			A2E1521	5	4					23							30										
			A2W1511		5			2		15	1			2			31										
			A2W1521		2					5	2						3										
		20	A2E2011		7					3							2								1		
			A2E2021		16												7										
			A2W2011		4						3																
			A2W2021		3			1			1						1										
		25	A2E2511		1					3	2																
			A2E2521		1						2																
			A2W2511		1	1					2																
			A2W2521		1											1											
		30	A2E3011								12														1		
			A2E3021		1						10																
			A2W3011								2																
			A2W3021		1										1						1						
21 July	A3	15	A3E1511		1					2	12					1				1							
			A3E1521					1		2	15																
			A3W1511	1	1			1		31		1					18										
			A3W1521		1					41	2						8									4	
		20	A3E2011		2						1																
			A3E2021		3																						

Table 1a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
2 August	A1	15	A1E1511		1	1						1					7										
			A1E1521	2		1											6										
			A1W1511							42							76			1							
			A1W1521							17							31				1						
		20	A1E2011		3						1																
			A1E2021		2																						
			A1W2011		4						3																
			A1W2021								1																
2 August	A2	15	A2E1511							61							16										
			A2E1521	6		1				23	2						88										
			A2W1511							13	1						6				1						
			A2W1521			1				28	3						6										
		20	A2E2011	1	12	1					1						11				1						
			A2E2021		8	3					2		1				1										
			A2W2011		9						1																
			A2W2021		3						1																
		25	A2E2511		4																						
			A2E2521		5																						
			A2W2511																								
			A2W2521		2																						
		30	A2E3011		1						9												1				
			A2E3021								14																
			A2W3011								4												1				
			A2W3021		2																						
3 August	A3	15	A3E1511	1						4	1						2										
			A3E1521					1		9	6						1										
			A3W1511			1				16	3						3										
			A3W1521	3	1					3			1				4										
		20	A3E2011		1						3			1		1											
			A3E2021	3	1	1																					

Table 1a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
18 August	A1	15	A1E1511							6						3	14										
			A1E1521							10						5	7										
			A1W1511					1		6					2		4										
			A1W1521							1	1				1		1										
		20	A1E2011							3																	
			A1E2021																								
			A1W2011		3										1	2											
			A1W2021					1							1												
23 August	A2	15	A2E1511	12				1		76	1					3	32	1									
			A2E1521	13						117	1					3	19										
			A2W1511			1		1		14	1					2	4										
			A2W1521					1		13	4						4										
		20	A2E2011		1	1					5						1										
			A2E2021		4										1	1											
			A2W2011		1					2																	
			A2W2021								1										1						
		25	A2E2511		1	2					6																
			A2E2521		5																						
			A2W2511																								
			A2W2521								1																
		30	A2E3011							3																	
			A2E3021							1	1																
			A2W3011								1																
			A2W3021		1																						
18 August	A3	15	A3E1511					1																			
			A3E1521					1		6																	
			A3W1511							18				1			7										
			A3W1521	1						7						2	5										
		20	A3E2011	14	1	1					1	1															
			A3E2021	6											1												

Table 1a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
8 September	A1	15	A1E1511	2		2		1								2	12										
			A1E1521	1		4				21					1		5										
			A1W1511													1	1				1						
			A1W1521																								
		20	A1E2011		2											3											
			A1E2021		1											1											
			A1W2011																								
			A1W2021													1											
8 September	A2	15	A2E1511	1						34	1				1		13										
			A2E1521	1		1				26						2	11										
			A2W1511	1						17					1	1	15										
			A2W1521			2				9					1	2	7				1						
		20	A2E2011			2				5							3										
			A2E2021							4						1											
			A2W2011													3											
			A2W2021							1						1											
		25	A2E2511		2										2	1											
			A2E2521			1				3	1																
			A2W2511							1					1												
			A2W2521							1						1											
		30	A2E3011								1																
			A2E3021		6						2																
			A2W3011		1						1																
			A2W3021																								
8 September	A3	15	A3E1511													1	1										
			A3E1521							2						1											
			A3W1511							10						1	16										
			A3W1521	11		2				5				1		3	8										
		20	A3E2011	1	1	1																					
			A3E2021					1							1												

Table 1a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
7 October	A1	15	A1E1511	3		1				15		1			1		6										
			A1E1521	1				1		4					1	2	4										
			A1W1511	9						17						1	10				3						
			A1W1521							15						2	3										
		20	A1E2011							1					1	1											
			A1E2021		2											1											
			A1W2011		7											1											
			A1W2021		4	2									1	1	1										
7 October	A2	15	A2E1511	212				1		14	4						41										
			A2E1521	123						4	1						32										
			A2W1511	45				1		3	1					1	13										
			A2W1521	8		2				6					1	1	7										
		20	A2E2011	1						13					1	2	4										
			A2E2021			1				7					1	3	1										
			A2W2011							6						2	2										
			A2W2021							3					1	1											
		25	A2E2511			1		1		3					1												
			A2E2521	1	1	1				5					1												
			A2W2511			1																					
			A2W2521																								
		30	A2E3011												2												
			A2E3021																								
			A2W3011							2					1	1											
			A2W3021																								
7 October	A3	15	A3E1511	16							1					3	1										
			A3E1521	10											1	3											
			A3W1511	3						1					1	5	1										
			A3W1521	7		2				7					2	5											
		20	A3E2011							2																	
			A3E2021													1											

Table 1a. (concl.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL
3 November	A1	15	A1E1511	11	48			4									7			1							
			A1E1521	9	22	6										1	8										
			A1W1511	21	28			2		7							19				1						
			A1W1521	20	29			2		9	1				1		14									3	
		20	A1E2011	3	5			1							1	3											
			A1E2021	1	7			1							2	3					1						
			A1W2011	18	49	1					1					2	6										
			A1W2021	10	74											2	3										
3 November	A2	15	A2E1511	51	1											2	18										
			A2E1521	74		2					1						46										
			A2W1511	52	16	3										1	22										
			A2W1521	25	15	1		1								2	17										
		20	A2E2011	76	4	3		1									6									2	
			A2E2021	60	5	5					1						2				1						
			A2W2011	17	6			1							1	4											
			A2W2021	9	3	1										3	1										
		25	A2E2511	17		1									1	2											
			A2E2521	5	2	1									1	1											
			A2W2511	5							1					1											
			A2W2521	2											1	2											
		30	A2E3011																								
			A2E3021	3	1											5					1						
			A2W3011	1																							
			A2W3021	1				2			1																
		35	A2W3511	5				1		2					2												
			A2W3521	1						2																	
4 November	A3	15	A3E1511	54	23	1					1					2											
			A3E1521	77	24	1		2			1					2	1										
			A3W1511	33	35	3		1								1	19										
			A3W1521	44	19	2		1			1						25										
		20	A3E2011	6						18					3	4											
			A3E2021	6						14					2	1											

Table 1b. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20-, 25- and 30-m depths (± 2.5 m) along Transects A1 and A2 in the north basin of Amisk Lake (North Amisk) during 1989. Blanks indicate zero counts.

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
7 May	A1	15	A1E1511	12	30	4		3	2								26										
			A1E1521	7	34	2		2	1							1	27										
			A1W1511	15	69	1		3			1						2				1						
			A1W1521	13	66			1													1						
		20	A1E2011	2	24	1									1												
			A1E2021	5	16	1		1								1											
			A1W2011	4	60	1									3	2											
			A1W2021	4	70								1		1	2					1						
7 May	A2	15	A2E1511	50													36										
			A2E1521	57		1					1						17										
			A2W1511	35	6			2			1						31		1		3	1					
			A2W1521	37	10	1		4									23										
		20	A2E2011	61	6				1								21										
			A2E2021	45	12			1	1								10										
			A2W2011	18	11	2										2	2										
			A2W2021	18	16	1																1					
		25	A2E2511	7											3	2											
			A2E2521	3				2		1						4											
			A2W2511	3											1	2											
			A2W2521	1	1	1	1								1	3											
		30	A2E3011	4	3										3	2											
			A2E3021	4	6											1											
			A2W3011	1	2										2	2											
			A2W3021	2												5	1										

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
25 May	A1	15	A1E1511	7	7			1	1								19										
			A1E1521	7	8	4		1	1								16										
			A1W1511	12	16			4			3				1	2	8						1				
			A1W1521	25	33	1		4		2	1		1			1	35	2			1						
		20	A1E2011	1	27	1		1							3	1											
			A1E2021	3	27			1	2							1											
			A1W2011	1	26			1																			
			A1W2021	3	27						1				1	3											
25 May	A2	15	A2E1511	59	3			1			1					1	32						1				
			A2E1521	71	4	1		1			2	1					56	1					1				
			A2W1511	29	6	1		1			1					2	27				1					1	
			A2W1521	31	17	1					2						22				1						
		20	A2E2011	36	11				1					1		2											
			A2E2021	37	12				3					1												1	
			A2W2011	13	15	2			2			1				1	2										
			A2W2021	12	24			1	2							1	1										
		25	A2E2511	7	6										1	2											1
			A2E2521	2	7									1	3	1											
			A2W2511	5	6						1				3	3											
			A2W2521	1	4										2	2											

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
12 June	A1	15	A1E1511	8	20	3		4									10				1						
			A1E1521	11	11	1		3		1							32				1						
			A1W1511	19	14			10			5					2	30										
			A1W1521	16	17			1			1						21						2				
		20	A1E2011	2	23	2		1																			
			A1E2021	3	30	2		1	1						2	2							1				1
			A1W2011	1	12						1																
			A1W2021		21									1													
12 June	A2	15	A2E1511	53	1					1		4		1			37										
			A2E1521	35	5			1									33				2						
			A2W1511	34	14	1		1						1		2	22										
			A2W1521	49	8			2			2	3					41										
		20	A2E2011	27	8											2	5										
			A2E2021	20	9	2		1							1	1											
			A2W2011	27	26	2					2						2			1			1				
			A2W2021	19	11	1					3				1	1	3										
		25	A2E2511	1	2					1						1											
			A2E2521	6	14						1				2												
			A2W2511		1						1			1		1	1										
			A2W2521												1	1											

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
23 June	A1	15	A1E1511	4	10	1											11						1				
			A1E1521	7	8	3		1							1	1	11						1				
			A1W1511	20	15			9			1			1			24						4	3			
			A1W1521	20	13			4			1						26	2					2				
		20	A1E2011	3	37	1									1	2							1				
			A1E2021	1	20			2							1	2							1				
			A1W2011		5			1															1				
			A1W2021		10																		2				
23 June	A2	15	A2E1511	38	6			1									30										
			A2E1521	41	6	1											36	1		1							
			A2W1511	24	14	1		1									14									1	
			A2W1521	19	18			1									13										
		20	A2E2011	45	8	1		1	1		2						36										
			A2E2021	57	6			2						1		1	44								1	3	
			A2W2011	1	5						1					1											
			A2W2021	5	6	1																					
		25	A2E2511	23	11	1																					
			A2E2521	19	19	1		1			1												1			1	
			A2W2511	3	8	1										2							1				
			A2W2521	5	3										1	2									1		

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
			A1E1511	8	9	2										1	10				1			1		1	
10 July	A1	15	A1E1521	8	15	1									1		25										
			A1W1511	16	9			8		1	1						18				2		1				
			A1W1521	18	6			8									15			1	2		1			3	
			A1E2011		11			2						1									1				
		20	A1E2021	2	14			2								1											
			A1W2011		10										1								1				
			A1W2021	3	20						1					2											
			A2E1511	44	12	1					2	2					28						1				
10 July	A2	15	A2E1521	26	4			1									25				1						
			A2W1511	25	5	1		2			1						26				3					6	
			A2W1521	27	12			3			1						33				2		2				
			A2E2011	17	10	1																	1				
		20	A2E2021	29	13						1			1									3			2	
			A2W2011	8	20												2										
			A2W2021		9																						
			A2E2511	1	5						1							1									
		25	A2E2521	4	10						1																
			A2W2511	1	11						1									1							
			A2W2521	2	9			1													1						

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
20 July	A1	15	A1E1511	7	16	3										1	24				3					1	
			A1E1521	8	13	3		2									39				2						
			A1W1511	10	9			3									18				2		1			1	
			A1W1521	17	10			1			1					1	28	1			2					3	
		20	A1E2011	3	11	1																		1			
			A1E2021	3	6			1													1						
			A1W2011	3	21	2					1										2						
			A1W2021	3	23			1			2					1											
20 July	A2	15	A2E1511	33	4			2			1						44	2			1					1	
			A2E1521	36	2			4	1		1			1			38										
			A2W1511	28	9	1		2			1						26				1					2	
			A2W1521	34	11	2											38				3					1	
		20	A2E2011	42	10	1					1				1		11										
			A2E2021	50	7	2											5						1				
			A2W2011	12	17						1						1				3						
			A2W2021	21	9	1		1									2				1						
		25	A2E2511	2	4																						
			A2E2521	15	2	3					1												1				
			A2W2511	1	1			1																1			
			A2W2521		4			1																			

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
3 August	A1	15	A1E1511	9	2			4									9				2						
			A1E1521	17	2	1		4									14				3						
			A1W1511	21	6			3		2	2	1					16				2						
			A1W1521	31	3			7		2							10				2						
		20	A1E2011	1	17						1						3										
			A1E2021	1	12	2		1			1																
			A1W2011	1	8						2										1						
			A1W2021		4																						
3 August	A2	15	A2E1511	35	3			2			2	1					46	1			1					1	
			A2E1521	48	1												40	2									
			A2W1511	19	6												17				4						
			A2W1521	22	3			1			1						28				1	1					
		20	A2E2011	42							1						37				1						
			A2E2021	43	3	2		1			1						1					1					
			A2W2011	6	8						2					1	1							1			
			A2W2021	12	3	4		1			1										2	2					
		25	A2E2511	35	1	3					1						1										
			A2E2521	24		4		1			2										1						
			A2W2511		6												1					1					
			A2W2521	1	4						1																

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
21 August	A1	15	A1E1511	7		4					1		1			1	3				1						
			A1E1521	3		3		1								2	6				1						
			A1W1511	6				3		4	1						4				2		1				
			A1W1521	14				6							1	1	2				2						
		20	A1E2011		2									1	1	1					2			1			
			A1E2021	1											2												
			A1W2011	12							3					1	2				1						
			A1W2021	19							2			1		1	2				2			1			
21 August	A2	15	A2E1511	32		1		1			2						90	5								4	
			A2E1521	33												1	49						1				
			A2W1511	22	1	1											1				1						
			A2W1521	22	1	2										3	70										
		20	A2E2011	43	1				1					1		2	1										
			A2E2021	45		4									2												
			A2W2011								3						1						1				
			A2W2021	8	2	3			1							2					1					1	
		25	A2E2511	4																							
			A2E2521	3																							
			A2W2511	3		1					1			1													
			A2W2521	8		1														1							

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
7 September	A1	15	A1E1511	6		1		1								2	10	1									
			A1E1521	5		1		1									2				3						
			A1W1511	8				5								1	17										
			A1W1521	9				1								1	6				1						
		20	A1E2011														1				1						
			A1E2021	1	1																						
			A1W2011												1												
			A1W2021																								
7 September	A2	15	A2E1511	20		1										1	29				1						
			A2E1521	31										1			2										
			A2W1511	7		1											2				1						
			A2W1521	9													15										
		20	A2E2011	18		1		1									5										
			A2E2021	15							1						7										
			A2W2011	2																							
			A2W2021	1		1		1								2											
		25	A2E2511	6																	1						
			A2E2521	5		2					1																
			A2W2511								1						1										
			A2W2521	1																							

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
1 October	A1	15	A1E1511	5		2		1								1	6				1						
			A1E1521	3		2		4									9				1						
			A1W1511	12				3								1	1				1						
			A1W1521	4				2								1			1		1						
		20	A1E2011					1								3											
			A1E2021	1											2	3											
			A1W2011																								
			A1W2021																								
1 October	A2	15	A2E1511	27		1					1						7				1						
			A2E1521	29		2				1					1	3	28				1						
			A2W1511	24				2									7										
			A2W1521	13		4											29				2						
		20	A2E2011	24													4										
			A2E2021	22											1		2										
			A2W2011	2											2												
			A2W2021												1												
		25	A2E2511	5											1												
			A2E2521	6				1								1											
			A2W2511			2										1											
			A2W2521	2																							

Table 1b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
31 October	A1	20	A1E2011	2	3	2		3									3				3						
			A1E2021	3		2		1									1				1						
			A1W2011	6	94	2		1								5											
			A1W2021	2	62											4	1				1						
31 October	A2	20	A2E2011	27	9	1		1									20										
			A2E2021	31	13	2										2	18									1	
			A2W2011	15	16						1					1	1									3	
			A2W2021	13	3	1									1	1	3										
		25	A2E2511	15	10	2		1																1			
			A2E2521	19	3	2										2											
			A2W2511	5		1										2					1						
			A2W2521	1	3	1		1			1				2	3											

Table 1c. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20-, and 25-m depths (± 2.5 m) in the north basin of Amisk Lake (North Amisk) during 1990. Blanks indicate zero counts.

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
9 May	15	N1511	4	9			6	3	5	1				1		13												
		N1512		11			10	5	9	2						14												
		N1521	5					14	1	3				1		20												
		N1522	6	2			1	11	2	3			1			14												
	20	N2011	7	7			3	37						1														
		N2012	2	2			1	1		1				1	4													
		N2021	3	12			2	4							2	1												
		N2022	1	3			3	8							1													
		N2031		18						1			1	1														
		N2032		18	1				2				1	1	2													
	25	N2511						1							1													
		N2512	2					1		1				1	2													
		N2521					6	1	1						2													
		N2522		1			1	2			1			2	2													
		N2531		1	1			6							3													
		N2532		2				1		1				1	1													
		N2541		1	1			1						1														
		N2542		6	2		1			1	1		1	1	1					1								
		N2551		9										1														
		N2552																									1	

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
26 May	15	N1511		7	1		7		4							37				3								
		N1512	5	8			3		5					1	3	4											1	
		N1521		7			5	3	2	2	1				1	49				1								
		N1522		7				1	1	2			1	1	1	21												
	20	N2011		9			3	2	1	2	1			1	1													
		N2012	2	8	2		3	1								2												
		N2021	1	8				1		1				1	1	9				1								
		N2022		5	1		3			1			1	1	1	4				1								
		N2031		16			1	1	1	1				1														
		N2032		17	1			1	5					1	1					1								
	25	N2511		3			1			1			1	1	2													
		N2512		6				2							1													
		N2521							1	1	1		2		2	2				1								
		N2522	2							1					1													
		N2531		1			1				2		1	3	1	2											1	
		N2532					1			1				2	1													
		N2541		3			1	1		2			2		2													
		N2542		3				3					1		1													
		N2551		5				3		1				1	4					2								
		N2552		9				7	2					5	2													

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
11 June	15	N1511		15	1		10		18	1	1		1	1	2	12											1	
		N1512		23			3		18	1	1		1		1	19												
		N1521		18	1		2		7	3			3			41	2	1				1					1	
		N1522		1			1		4	5						25												
	20	N2011		10			4				1	1		1		1						1						
		N2012		9			3						1		1	1												
		N2021		7					1						1							1						
		N2022	1	8						1				1		1						1						
		N2031		4					5	1			1		1													
		N2032		8						1				1														
	25	N2511		4			3			1										1								
		N2512		8			1																					
		N2521		3	1					1			1															
		N2522							1	2			2															
		N2531		2						2					4													
		N2532		2			2			1					1													
		N2541		8						1									1									
		N2542		6	3		7																					
		N2551		2						2	1				1													
		N2552		3			1							2	1													

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
22 June	15	N1511		8											2	2												
		N1512		6			4		3				1			3												
		N1521							1	1						5				1								
		N1522	1	4					2							20	1											
	20	N2011		6	1		4				1											1						
		N2012		2	1		3																					
		N2021		6																1								
		N2022		7									1														1	
		N2031		7							2	1			1													
		N2032		3			1			1					1													
	25	N2511		2																								
		N2512	1	4										1													1	
		N2521		2			1		1																			
		N2522																										
		N2531									1		1															
		N2532	1	1					1						1													
		N2541		4						1					1													
		N2542		8	1																							
		N2551		4						1																		
		N2552		2																		1						

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
10 July	15	N1511		6	1		4		10			1				9				1								
		N1512		10	1		8		5							12						2						
		N1521		1					57	1						7	1											
		N1522		4					44		1					12												
	20	N2011		10					6							2				2								
		N2012	1	16					9	4	1					5												
		N2021		9					6	2								1										
		N2022		4					5	1					1	2												
		N2031		8	2				25						1			2		1			1			1		
		N2032		10	3				13																			1
	25	N2511		10			1		3	1		1			1													
		N2512		3																								
		N2521	1	4			2		3	1		1								1								
		N2522		8	1				7	1				1														
		N2531		2			2		8	1								1				2						
		N2532							7	2			1					1										
		N2541		9	2				9	1																		
		N2542		7	3		3		15		1	2								2								
		N2551		7	2				5	2									1									
		N2552		8	2		1		9	4						2												

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
19 July	15	N1511		17	1		13		20							16												
		N1512		11	2		4		5						1	5	1											
		N1521	3	4			1		86							37												
		N1522		7	4		1		59	3			1			32												
	20	N2011		15	1		3		24		1					3				3								
		N2012		9	4		5		31							3												
		N2021																										1
		N2022		5			2		7		1					1				1								
		N2031		13	2		4		31	1						1					1	1						
		N2032		8	2		2		43	2		1					1											
	25	N2511		6	3		2		3	1												1						
		N2512	1	6					1		1	1										1						
		N2521		4					5		1								1									
		N2522		2	3		1		6				1							1								
		N2531	1	5	2		1		19													1						
		N2532	1	3					11	1									1									
		N2541		9	6				19	2		1	1		1	3				1								
		N2542		7	4		1		38	2		1	1							2		2	1					
		N2551		12			1		13	2			1		1				2									
		N2552	1	7					8	2					1	5			1	1								

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
3 August	15	N1511					4		33							40						1						
		N1512			2		2		30		1					16												
		N1521		2					6			1				7				1								
		N1522	9	2	4				23		1					11				1								
	20	N2011	2	2	9		2		21	1	1																	
		N2012		7	1				3																			
		N2021	4	1			1		4						1					1								
		N2022	11	7	7		1		9							13				1								
		N2031	11	2	2		1		118			1				2		1										
		N2032	6	1	4		2		126							2						1						
	25	N2511	9	4	2		1				1																	
		N2512		5						2						1				1								
		N2521	7	4	3		1													1								
		N2522	1	4	2				1																			
		N2531	1	2					1																			
		N2532		2			2		21							1						1			1			
		N2541	8	1	3				22					1		2		2										
		N2542			3				33										1	2								
		N2551		3	8		1		30	1								1		3								
		N2552		3	5				23	2						2												

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
16 August	15	N1511	1				1		43							12				4								
		N1512					4		29	1						7				2								
		N1521	21						22	1	1				1	14				2								
		N1522	8				1		13						2	3												
	20	N2011	15		5		1				1			1	1	1												
		N2012	22		3		2									2				2								
		N2021	8					2				1		2														1
		N2022	14		6		1									3												
		N2031	84	1	2		2								1													
		N2032	77	1	2		5			1					1					1								
	25	N2511	6		1		1																					
		N2512	5		3		1													1								
		N2521	14																									
		N2522	14		3																							
		N2531	15				3							1														
		N2532	44	2			4					1				2												
		N2541	32		8																				1			
		N2542	63	1	9						1		1			4								1				
		N2551	23		2		7											1										
		N2552	8	1	1		4	1								1		1										

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
11 September	15	N1511	55		3		2		52					1	3	29				1								
		N1512	4		1				55					1	3	14				1								
		N1521	22		6		1		11	1					1	33				2								
		N1522	15		1		2		7	1					3	10												
	20	N2011	4		1		1							1	2	1				2								
		N2012	33		11	1	4			1						10												
		N2021	9		3		1							3														
		N2022	16		15		2								3					3								
		N2031	48		4		1								3													
		N2032	96		1					3										1								
	25	N2511	4		7					2				2	1													
		N2512	7		8		1			1				1	3													
		N2521	1		2		1																					
		N2522	10		7		1								2													
		N2531	45		3					1										1								
		N2532	22		1										1													
		N2541	30		5						1									1								
		N2542	50		9		1			1				2										1				
		N2551	15		3										1													
		N2552	10		3					1																		

Table 1c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
11 October	15	N1511	29	2	1		4	1	10	2				1	1	17	1											
		N1512	17		2		3		34	1				3	1	15				4					1			
		N1521	27		5		1		6	5						30												
		N1522	27		3				7	4				1		25				1								
	20	N2011	18	2	8		1							2	4													
		N2012	20	10	7		1			1				2	4													
		N2021	37	3	4									1	5	1												
		N2022	52	15	4					1				3	5	1												
		N2031	145	22	2					1				1														
		N2032	99	36	2					4		1				1												
	25	N2511	8		3		1								1													
		N2512	5		1										1													
		N2521	11		10										1													
		N2522	16		3		1							1	1													
		N2531	45											1	3													
		N2532	37		3		1			1					2													
		N2541	59		10					3					2						1							
		N2542	80	6	4					1							1				1							
		N2551	43	13	8					1				2	3													
		N2552	46	26	5																							

Table 1c. (concl.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
6 November	15	N1511	36	3	1		7		24	10	1					52				1					1			
		N1512	40				8		14	16				1		26	3											
		N1521	13	3	1		1		9	4				1	1	16												
		N1522	28	3	2		6		21	4					6	51												
	20	N2011	56	18	12		1			1						15												
		N2012	46	20	12		1			3			1	1	1	10				2								
		N2021	27	36	6		1			5			1		4	10				1					9			
		N2022	39	10	10					1					2	10									1			
		N2031	53	23	10					4					1	2				1					1			
		N2032	91	82	6		2			4										1								
	25	N2511	25	13	12					1				2														
		N2512	5	13	8									1	1													
		N2521	12	7	4					1					3										1			
		N2522	20		4									2														
		N2531	62	1	2					4				1	2													
		N2532	63	1	1					2				1	3										2			
		N2541	81	31	9					1				1											2			
		N2542	95	54	10					3				1											1			
		N2551	36	20	17					3					1					1								
		N2552	46	28	20		1			3					1	1				1								

Table 1d. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20-, 25-, and 30-m depths (± 2.5 m) in the north basin of Amisk Lake (North Amisk) during 1991. Blanks indicate zero counts.

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
6 May	15	N1511	44		3		3			8						30										
		N1512	52		2		2			20						18	1									
	20	N2011	8	14	4		3	1						1	2					1						
		N2012	10	22	7		3							1												
		N2021	68	8	5		1	1		20				1		27			1							
		N2022	109	3	1		8			6					1	12										
	25	N2511	10	13	2		2	2		2				1												
		N2512	25	10	3		5	4							2											
		N2521	25	2				2							1	1										
		N2522	31	2	1		1	1								1				1						
		N2531	58	10	6					1					1											
		N2532	67	11	11			5		1						1										
21 May	15	N1511	21	1	4			4		2						50				1						
		N1512	14	2	5		3	7		13				1	1	50										
	20	N2011	7	24	10		6							1	1											
		N2012		34	5		6	3						1	2											
		N2021	88	5			7	2	1	7						1										
		N2022	80	2	7		6	2		1					1	4										
	25	N2511	11	9	1		5	8		1						1										
		N2512	12	7			1	5						1												
		N2521	49		3		2	4		2					1											
		N2522	46	10	3		1	4									1									
		N2531	108	6	6		4	9		4			1		1	6					1					
		N2532	116	8	13		1	2		3						9										
	30	N3011	16	14	6					1	1			1												
		N3012	23	15	5			4		3				2	1						1					

Table 1d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
28 May	15	N1511	32	5	5		1			5					1	43										
		N1512	31	1	4		5	4		9	1				1	53						1				
	20	N2011	7	44	12		1	3		2				2	1											
		N2012	1	49	14		2	5		1				1												
		N2021	88	20	4		3			1				2	1	1										
		N2022	98	21	6		1	1		1					1	2										
	25	N2511	6	21	17			1		1						1	1			1						
		N2512	4	11	4		1	2		1				1												
		N2521	24	3	1		1	3		3				2	2											
		N2522	37	5	1		1																			
		N2531	118	10	18		2	6		2																
		N2532	109	13	17					1																
11 June	15	N1511	15	9	5		3	1		1						49				1						
		N1512	20	7			5			2				1		81	2									
	20	N2011	4	57	16		16			4			1		1											
		N2012	13	73	8		5			7			1							1						
		N2013	7	47	3		1						1							1				1		
		N2021	47	5	1		2			3			1			7										
		N2022	84	3	4		7			1					1	33									1	
	25	N2511	4	28	2		1			4	1				1											
		N2512	16	18	2		1			2				1	1							1			1	
		N2521	13	3			1			1	1		1	1	1	1			1	1						
		N2522	29	3						1						1						1				
		N2531	100	13	19		3			1																
		N2532	102	4	10		2			4						7										

Table 1d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
25 June	15	N1511	11	6	1		7	1								50										
		N1512	18	4						3	1			1		13										
	20	N2011	14	33	14		4			2			1													
		N2012	5	35	9		3													1						
		N2021	74	2	3		3			2		1	1	1												
		N2022	87	5	2		3			1				1		1										
	25	N2511	8	20	3		3			5					1		1			1						1
		N2512	9	19	1		5			1	1						2									
		N2521	75	13	9		1								1											
		N2522	60	7	11		3			1																
	30	N3011	4	15	3		1			1																
		N3012	11	15	5		1			2																
9 July	15	N1511	26	13	3		2				1					40										
		N1512	32	14	2		6			1						73										
	20	N2011	4	9	23		6																		1	
		N2012	6	15	20		7							1		1										
		N2021	90	7			1			2	1		1			89										
		N2022	84	3			1				1				1	89										
	25	N2511	10	19	1					1																
		N2512	3	11		1									2											
		N2521	71	5	15		4			5				1		2									5	
		N2522	119	9	16		1			8						6									6	

Table 1d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
23 July	15	N1511	14	12	1				1	1					2	24										
		N1512	19	14			3		4							86	1			1					1	
	20	N2011	10	8	18		5						1			1			1	2						
		N2012	5	5	4		2													1				1		
		N2021	91		1		1									44		3								
		N2022	93	4			1			4						25										
	25	N2511	1	6						1																
		N2512	4	15	4		1																			
		N2521	55	12	7		4			4						2										
		N2522	70	6	11		1			2						3									1	
	30	N3011	3	4	1					1																
		N3012		6	1																					
6 August	15	N1511	55	8	2		3		7		1					67										
		N1512	43	11	4		1			1						49										
	20	N2011		3	5		5																			
		N2012	2	3	6		2							1						2						
		N2021	62		4		9			3						9				1			1			
		N2022	82	3	4		2			1		1														
	25	N2511	7		6		1			1																
		N2512	4		3															1						
		N2521	76	2	8					2															4	
		N2522	35	3	14		1			1										1					4	

Table 1d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
20 August	15	N1511	25		3	2			4							96										
		N1512	29	1	9	4			2						2	32										
	20	N2011	13		33	7										1										
		N2012	6	1	14	1														2						
		N2021	90		1	3				3																
		N2022	89		5	9				3						1				1						
	25	N2511	12		1	1				2																
		N2512	16		2	1				2																
		N2521	89		8	1				3						4									1	
		N2522	66		10					3						1	1								3	
	30	N3011	42	2	6	2				1		1														
		N3012	58		7	1				1										2						
6 September	15	N1511	12		5	2								1	2	89										
		N1512	23	1	8	2								1	1	43										
	20	N2011	9	2	10	9																		1		
		N2012	3		8	5								3												
		N2021	76		10	12										1				1						
		N2022	74	1	3	13				1				3		1										
	25	N2511	11		2	1								1												
		N2512	8		1					2																
		N2521	78		15	1									1	5										
		N2522	43	1	13	1				1																

Table 1d. (concl.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH
17 September	15	N1511	25	1	2		2									49										
		N1512	19		4											12										
	20	N2011	10		20		2							2	3					1						
		N2012	6		32		2							1	1					1			1			
		N2021	66		4		9			1						1				1						
		N2022	60		7		10			2		1								1						
	25	N2511	2		2		1													1						
		N2512	5											2												
		N2521	47		12	1				1																
		N2522	66		9		1									1										
	30	N3011	2							1																
		N3012	2							1																
1 October	15	N1511	7		3		1							1	2	16										
		N1512	49		11		10								1	228										
	20	N2011	5		17		8							2	3					1						
		N2012	16		21		13																			
		N2021	38		4		7			1				2												
		N2022	49		9		12							1		1				1						
	25	N2511	5		2																					
		N2512	5		1																					
		N2521	78		4					1				1												
		N2522	68	1	7									1		1										
		N2523	66		9		2			1						5										
29 October	20	N2011	20	4	44															1					1	
		N2012	13	19	41		7							1												
	25	N2521	70	3	13											2				1						
		N2522	59		5											1										

Table 2a. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20-, 25- and 30-m depths (± 2.5 m) along Transect A4 in the south basin of Amisk Lake (South Amisk) during 1988. Blanks indicate zero counts.

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH	GAM
25 May	A4	15	A4E1511	1	1						2	1					18											
			A4E1521	4		5			2								45											
			A4W1511			1		1			1	2					16	1										
			A4W1521	1	3			1	1		1		1	2			42											
		20	A4E2011	2		7										1	35											
			A4E2021	4		9											19											
			A4W2011	1	1											1	1											
			A4W2021		1	4										1	2											
		25	A4E2511			1											2											
			A4E2521			1																						
			A4W2511								2																	
			A4W2521			1	1								1		5											
		30	A4E3011												1										1			
			A4E3021																									
14 June	A4	15	A4E1511							1						1	3											
			A4E1521	1		4					1			1			31											
			A4W1511	3	6	3		4			3		1	1			70	2		1								
			A4W1521		3	2		3			4	1	1	1			38		1									
		20	A4E2011			3								1			1											
			A4E2021	1		1											5											
			A4W2011			2		2							1		22				1							
			A4W2021		1	1					2			1			26											
		25	A4E2511		1																		1					
			A4E2521			1																						
			A4W2511		1	5									1	1	11						1	1				
			A4W2521		2	1					3			1									1					
		30	A4W3011		2										1	1								1				
			A4W3021		1						1																	

Table 2a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH	GAM
28 June	A4	15	A4E1511	1	1	1					1			5		1	48	1										
			A4E1521	1		1					1			1			30											
			A4W1511	1	3			1			2	1		1			18	2										
			A4W1521	3	1			3			4			2			66	1						1				
		20	A4E2011			7			1								1				1							
			A4E2021			3											1											
			A4W2011					2			1						9											
			A4W2021			1					1			1			4											
		25	A4E2511			1					1						1											
			A4E2521			2				1	1						1											
			A4W2511	1							3						3											
			A4W2521		1		1				1			1			1											
		30	A4E3011		1						1																	
			A4E3021																					1				
			A4W3011		2						2																	
			A4W3021								2																	
12 July	A4	15	A4E1511			1				4							7											
			A4E1521	1		1				15	1						19											
			A4W1511	1	3	1				27	3	1					18									1		
			A4W1521	1	3	5		1		26	2	4					24											
		20	A4E2011			2					1						10											
			A4E2021			13					1						48											
			A4W2011		1		1				3						14											
			A4W2021	1	1	2											31											
		25	A4E2511																									
			A4E2521							1	1																	
			A4W2511	1							2						3											
			A4W2521		2	2																						
		30	A4E3011		1											1											
			A4E3021																					1				
			A4W3011																									
			A4W3021		1																							

Table 2a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH	GAM
26 July	A4	15	A4E1511	1		5				65	3	1					88											
			A4E1521	3		1				34	3						42				1							
			A4W1511	5	1	1		1		74	1	5					92	5										
			A4W1521	4		1		5		74	7	2		1			37	3										
		20	A4E2011			3											2											
			A4E2021			3											3											
			A4W2011	2	1	3					5						50											
			A4W2021	2	1	1					4						34											
		25	A4E2511								1																	
			A4E2521																									
			A4W2511		3																							
			A4W2521																									
		30	A4E3011														1											
			A4E3021																									
			A4W3011																									
			A4W3021		1																							
4 August	A4	15	A4E1511			2				6	4			2			7											
			A4E1521			2				3	2						11											
			A4W1511	2				1		23	2			1			14							1				
			A4W1521	3						21	2						20											
		20	A4E2011			24					1						20											
			A4E2021			12					1						15											
			A4W2011	1	3	1				1							9			1								
			A4W2021		4												11											
		25	A4E2511																									
			A4E2521			1																						
			A4W2511		2										1		9											
			A4W2521																									
		30	A4E3011																									
			A4E3021																									
			A4W3011																									
			A4W3021																									

Table 2a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH	GAM
24 August	A4	15	A4E1511	1						48	1			1		2	18				2							
			A4E1521	2		1				38	2						54	3			1							
			A4W1511	2		1				43		1			1	1	32											
			A4W1521	5				1		73				1		3	36											
		20	A4E2011					1								1	2											
			A4E2021	1													2											
			A4W2011			3										2	19										1	
			A4W2021	1		1										1	14							2				
		25	A4E2511			1										1					1							
			A4E2521			2											4				1							
			A4W2511		3									1														
			A4W2521		3												1											
		30	A4E3011												1									1				
			A4E3021												1	1												
			A4W3011																									
			A4W3021																									
9 September	A4	15	A4E1511			1				58						2	48											
			A4E1521	2		3		1		42						2	34	1										
			A4W1511	2		1				40	1						30	1			1							
			A4W1521	1						94	2						31	3										
		20	A4E2011			3								1		2	15				1							
			A4E2021			11				1							29											
			A4W2011	1	1	1					1					1	19											
			A4W2021													1	42											
		25	A4E2511			1																						
			A4E2521	2		4								1		4	3											
			A4W2511		1									1			3			1								
			A4W2521																									
		30	A4E3011																									
			A4E3021																									
			A4W3011																									
			A4W3021											1														

Table 2a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	EPH	GAM
8 October	A4	15	A4E1511			8				7							33											
			A4E1521	5		7				7	1						29											
			A4W1511	24						16							65	1										
			A4W1521	27				3		26	2						35											
		20	A4E2011		3	2										2	18											
			A4E2021			1										1	9											
			A4W2011	4	1	5				8						1	101				1							
			A4W2021	8		5								2			35											
		25	A4E2511			6											6											
			A4E2521		1											1	1											
			A4W2511	1	1											2												
			A4W2521		2	1											3											
		30	A4E3011																									
			A4E3021																									
			A4W3011													1												
			A4W3021																									
4 November	A4	15	A4E1511	115							3	1					100		1									
			A4E1521	89		4		1									66						2					
			A4W1511	45		2					1			1		2	53											
			A4W1521	63	1	5					1			1		2	18		3	3			1		19		2
		20	A4E2011	7		4										2	3											
			A4E2021	7		3																						
			A4W2011	3		3										1	12											
			A4W2021	10	1											2	14											
		25	A4E2511	8		3										1	1											
			A4E2521	1		3										1	1											
			A4W2511	5	1	1				6						1	3											
			A4W2521		3	5		1									4											
		30	A4E3011	2						1																		
			A4E3021																									
			A4W3011													1												
			A4W3021																									

Table 2b. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20-, 25- and 30-m depths (± 2.5 m) along Transects A4 and A5 in the south basin of Amisk Lake (South Amisk) during 1989. Blanks indicate zero counts. Transects A4 and A5 were located at the near and far ends of South Amisk, respectively (Fig. 3.1).

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
12 May	A4	15	A4E1511	54	1	10			6								63											
			A4E1521	61		7			3			1					29	1										
			A4W1511	75							3			1			36	2										
			A4W1521	77				1			1					1	49											
		20	A4E2011	2	1	2										2	1											
			A4E2021	5	1	13			4					1			9											
			A4W2011												1	1												
			A4W2021	1		1											1											
		25	A4E2511											1														
			A4E2521																									
			A4W2511		1																							
			A4W2521																									
		30	A4E3011																									
			A4E3021											1														
			A4W3011																									
			A4W3021											1														
11 May	A5	15	A5E1511	55	5	3		3									22											
			A5E1521	49	1	1		3			5						20											
			A5W1511	75		30										1	33											
			A5W1521	42		45			1								38											
		20	A5E2011	2	2	5																						
			A5E2021	4		4																						
			A5W2011	3		6			1							1	3											
			A5W2021	1		4																						

Table 2b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
26 May	A4	15	A4E1511	53		3								1			44	1										
			A4E1521	40		8											20									1		
			A4W1511	81		1		3			2	5		1			56	4										
			A4W1521	64				1			5	2				1	65	5			1							
		20	A4E2011	4		6								1														
			A4E2021	9		5																	1					
			A4W2011	15	1	3								1			24											
			A4W2021	4	3	3					1						4											
		25	A4E2511																									
			A4E2521								1																	
			A4W2511	1	1												1											
			A4W2521	1		1					1						1						1					
26 May	A5	15	A5E1511	59	1	3		2			1						52	1										
			A5E1521	60		3		6			3					1	40	1										
			A5W1511	50							2						42	5			1							
			A5W1521	43		2					1						41											
		20	A5E2011	8	4		1									1	37											
			A5E2021	8	1						1					1	35									1		
			A5W2011	5		24											4											
			A5W2021	10		20					1						6											

Table 2b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
14 June	A4	15	A4E1511	106	2	2		1						1			40	1								1		
			A4E1521	74		3						1					45	1										
			A4W1511	82	2			6			3	4		1			72	3		1						1		
			A4W1521	42				1			2			1			31											
		20	A4E2011	49		18		1									33											
			A4E2021	51		12											17							1				
			A4W2011	10		4					1						13	1										
			A4W2021	29	2	10										1	47											
		25	A4E2511	1							1												1					
			A4E2521			2																						
			A4W2511		2																							
			A4W2521		1																							
14 June	A5	15	A5E1511	60		1					2	1					64	9										
			A5E1521	41		2		3			1						34	4										
			A5W1511	21	1	34											22											
			A5W1521	12	1	23											25						1					
		20	A5E2011	10		5										1												
			A5E2021	3							1					1												
			A5W2011																									
			A5W2021		1	2											5			1								

Table 2b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
24 June	A4	15	A4E1511	71	1	6					1						45											
			A4E1521	75		7											21									2		
			A4W1511	77		1		4			3	4					70	3								1		
			A4W1521	61	1			1			2						54	3					2					
		20	A4E2011	1		8																	1					
			A4E2021	7		19											8											
			A4W2011	2	2	3					1						4											
			A4W2021	8	1	2					2			3			3											
		25	A4E2511																				1					
			A4E2521			1																	1					
			A4W2511								1																	
			A4W2521		1	1																						
24 June	A5	15	A5E1511	43		12										1	24						1			1		
			A5E1521	36		11					1						16	2								1		
			A5W1511	47		13					1						59						1					
			A5W1521	41		18		1									38	1										
		20	A5E2011	1												1							2					
			A5E2021	3	2	10		1									1				1		1					
			A5W2011	3	2	12					1						6				1							
			A5W2021	11		14						1					10	1					4					

Table 2b (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
12 July	A4	15	A4E1511	53		14						2					21				1			1		4		
			A4E1521	31		12										1	22						1	1		1		
			A4W1511	48	1			3			1			1		1	41	2		1						1		
			A4W1521	47		1		3			1	1		1			59	5										
		20	A4E2011	1		7										1	4											
			A4E2021	4		9											3											
			A4W2011	9		5					1						18	2		1								
			A4W2021	6	1	5					3					1	8							1				
		25	A4E2511																									
			A4E2521																									
			A4W2511			2					1																	
			A4W2521											1										1				
12 July	A5	15	A5E1511	32	1	1											15	3						2				
			A5E1521	40	1			1									44							1				
			A5W1511	36		8		1			1						23											
			A5W1521	53		5		3									48						1			1		
		20	A5E2011	7		4															1							
			A5E2021	6		12																						
			A5W2011	15	1	15								1			27											
			A5W2021	4		5	1							2		1	8											

Table 2b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
21 July	A4	15	A4E1511	40	1						1			1			48											
			A4E1521	37	39			1			1						45				1			2		3		
			A4W1511	41				3			1	1					36						1	1				
			A4W1521	41							2						35	2								7		
		20	A4E2011	9		9											16											
			A4E2021	19		10											17											
			A4W2011	42		3					2						29							1				
			A4W2021	56		4		1						1			74			1	2							
		25	A4E2511	4		1											1			2				1				
			A4E2521	4		2											1											
			A4W2511		1	1					2			1									1					
			A4W2521	1		1					1					1				1			1					
21 July	A5	15	A5E1511	26		16		1									32			2								1
			A5E1521	30		10		1			1			1			25						1			1		
			A5W1511	43		7		1									60	2					2			1		
			A5W1521	34		5		1									37	1								1		
		20	A5E2011	9		3					1						1			3								
			A5E2021	10		12					1	1		1			4							2				
			A5W2011	16		20					1						32											
			A5W2021	12		24					1						32									1		

Table 2b (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
4 August	A4	15	A4E1511	39		10											10											
			A4E1521	57		7					2					1	25									9		
			A4W1511	68		1		1		1	1						61							1		3		
			A4W1521	48	2		1			1	2	1		2			52	1								1		
		20	A4E2011	16		4										1	6											
			A4E2021	23	1	13											15											
			A4W2011	37		3					3			1			73											
			A4W2021	34		2					2			1			23											
		25	A4E2511	1																								
			A4E2521																									
			A4W2511		2																							
			A4W2521		5									1														
4 August	A5	15	A5E1511	22				1			1					1	12											
			A5E1521	39		3		1								1	18											
			A5W1511	18		4											15	1										
			A5W1521	39		20										1	39											
		20	A5E2011	3		3					1						2											
			A5E2021	7		3					2												1	1				
			A5W2011	4		24					2						5											
			A5W2021	6		5											2											

Table 2b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
23 August	A4	15	A4E1511	39		7											4											
			A4E1521	55		13								1			3											
			A4W1511	43		1		1			2	1				2	53	1										
			A4W1521	45	1						1			1		2	54	4	1									
		20	A4E2011	5		5										1	1											
			A4E2021	6													3											
			A4W2011	15		10					1						9				1							
			A4W2021	19		3					4						21											
		25	A4E2511			1																						
			A4E2521													1												
			A4W2511	3	5												1			2								
			A4W2521	2	3	3															1							
24 August	A5	15	A5E1511	15				1							1	2	1											
			A5E1521	25		2		2									11	1										
			A5W1511	8		8										3	4											
			A5W1521	27		2		1							1	1	43	3									1	
		20	A5E2021	4		1																						
			A5W2011	3		5					2						3											
			A5W2021	5		6									2	1	4											

Table 2b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
8 September	A4	15	A4E1511	17		3		1							1	1	6											
			A4E1521	10		2										1	6											
			A4W1511	34												2	7							1				
			A4W1521	39												1	3											
		20	A4E2011	1		2										1	2			1								
			A4E2021			2											2											
			A4W2011	17		6									2		10											
			A4W2021	12		2										1	8											
		25	A4E2511																									
			A4E2521																									
			A4W2511		3	1																						1
			A4W2521												2	1												
8 September	A5	15	A5E1511	11		1		2							1		2	1										
			A5E1521	26		3		2									33											
			A5W1511	18		2										3	1											
			A5W1521	17		1											70	2										
		20	A5E2011			2											2											
			A5E2021	1												1												
			A5W2011	13		9										1												
			A5W2021	1		11											1											

Table 2b (cont.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CUl	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
2 October	A4	15	A4E1511	56		1					1					4	51											
			A4E1521	54		2										1	16											
			A4W1511	33		1									1		12											
			A4W1521	45		2											16											
		20	A4E2011	4		1											6											
			A4E2021	1		4										2	1											
			A4W2011	23		2											23											
			A4W2021	10		3					1						19											
		25	A4E2511	2		14											2					1						
			A4E2521			6										1	4											
			A4W2511																									
			A4W2521	1	3	1									1	4												
2 October	A5	15	A5E1511	34		5									1	3	16										1	
			A5E1521	33		2									1	1	20										1	
			A5W1511	36		2									1	1	16	2										
			A5W1521	20		5										2	8											
		20	A5E2011	1	1	1									1		1											
			A5E2021	4		4										1								1				
			A5W2011	8		6	2									2	10							1				
			A5W2021	2		4											9											

Table 2b. (concl.)

Date	Transect	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
31 October	A4	20	A4E2011	7	1	10											7											
			A4E2021	8		7				2							6											
			A4W2011	10												1	20										
			A4W2021	2	2	3					1				1	2	1											
		25	A4E2511																									
			A4E2521																									
			A4W2511																									
			A4W2521													3												
1 November	A5	20	A5E2011	2		1									1	4	3									1		
			A5E2021	1	1										1	2												
			A5W2011	3	2	24										1	13											
			A5W2021	4	1	21					1				2		19											

Table 2c. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20- and 25- m depths (± 2.5 m) in the south basin of Amisk Lake (South Amisk) during 1990. Blanks indicate zero counts. Grab numbers S1511, S1512, S2011, S2012, and S2511 to S2542 were collected at the far end of South Amisk, while numbers S1521, S1522, S2021 to S2032, and S2551 to S2592 were collected at the near end of South Amisk (Fig. 3.1). Grabs marked with '*' were collected with a 523 cm² Ekman dredge.

Date	Depth (m)	Grab	ANT	DEC	CUI	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
10 May	15	S1511	1	2	3		2	7	1							24	1										
		S1512	5	1	1		1	9	4					1		64	1			1							
		S1521	1	27	4			5		2						20						1					
		S1522	1	33	1			1		3						15						2					
	20	S2011		5	12			14							1	8											
		S2012	2		15			6								15											
		S2021		1									1														
		S2022		1	1			1												1							
		S2031						1																			
		S2032			6											4											
	25	S2511		4	1																						
		S2512		2																							
		S2521						1							2												
		S2522		1																							
		S2531		2				1																			
		S2532		2				2		1					1												
		S2541		2											1	1											
		S2542		2									1		2												
		S2551														1											
		S2552																									
		S2561		2											1					1							
		S2562							1					1													
		S2571													1												
		S2572		1																							
		S2581													1												
		S2582																									
		S2591			1			1																			
		S2592	1		2																						

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
27 May	15	S1511	1	4	4			1							1	27											
		S1512	1		5		1		1	1					1	27	1										
		S1521		5	1		3	1		3						37	1			2		1					
		S1522		2			3		2		2			1	1	54	1										
	20	S2011		8	3	1									3	3											
		S2012		6				1	1						2	11											
		S2021		4			1									1											
		S2022		2					1				1				1										
		S2031			28					2			1		1	30											
		S2032		2	8			2			1		1			7											
	25	S2511		4		1				1			1		1												
		S2512		1						1				1													
		S2521			2									1	1												
		S2522											1		1												
		S2531		1						1																	
		S2532												1													
		S2541			1																					1	
		S2542			1			1					1	1												1	
		S2551		1						1			1													2	
		S2552																									
		S2561		1						1					2	1										1	
		S2562								1				1													
		S2571																									
		S2572											1														
		S2581		1																							
		S2582																									
		S2591			1					1						1											
		S2592			3			1		2																	

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
14 June	15	S1511	1	1	6		1									46											
		S1512	1	1	7											30											
		S1521*		3	6		1		1	6	2		1			60	1			1		2					
		S1522*		6	2					2			2	1	1	55						1					
	20	S2011		1												1						1					
		S2012		1	1					1						1											
		S2021*		3	1											5						1					
		S2022*		4	5					2			1	1		28										1	
		S2031*		7		1	1		1				1		1	24			1							1	
		S2032*		4					1					1	1	10				1			1				
	25	S2511		2												1											
		S2512		2						1										1							
		S2521		3	2										1								1				
		S2522		2									1														
		S2531																									
		S2532								1			1														
		S2541													1						1	2					
		S2542		1						1																	
		S2551		1						1			1	1													
		S2552		1						2																	
		S2561			1																		1			1	
		S2562		2						2	1			1												1	
		S2571											3						1				1			1	
		S2572										1															
		S2581*			2				1	2										1		1					
		S2582*			1					3	1	2	1		1						1	1				1	
		S2591*			2					3		1	1		1	3										1	
		S2592*			4				1	1						2				1		4				1	

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
26 June	15	S1511	4				2		5							20	3										
		S1512			5		1		1							21	1					1					
		S1521	1	1												10											
		S1522		5	1				1						1	31											
	20	S2011		3	2					1						3											
		S2012		5	2					1						18											
		S2021	6		5											14	1										
		S2022	3		10					1						8											
		S2031		1											1	4											
		S2032											1														
	25	S2511								1																	
		S2512		2						1						1										1	
		S2521			1										2											2	
		S2522			1																	1					
		S2531		2																		1					
		S2532																									
		S2541																									
		S2542																									
		S2551		1						1					1							1					
		S2552								1	1		1														
		S2561																									
		S2562		1											1		1										
		S2571											1														
		S2572		1																							
		S2581		1	1																						
		S2582			6											13											
		S2591		1	14				1							20											
		S2592			2										1												

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
11 July	15	S1511	7		24				58		1		1		1	48							1				
		S1512	5	2	22				19	1	1		1		1	30	1										
		S1521		3					101			4	5			28	2	2								1	
		S1522		5					102			3	1			15	1	2									
	20	S2011	1	1	4	2			4							10			1								
		S2012		5	2				4							11							1				
		S2021		1	3				6	1					1	12		2									
		S2022	3	1	1				6							2						1				1	
		S2031	1	4	1				15	2	1					3	1					1					
		S2032	2	5	1				15	1			1			9											
	25	S2511		1	1				7				1														
		S2512		1	2				1	3																1	
		S2521		1	9				6													1					
		S2522		1	3				4	1					1												
		S2531								1																	
		S2532		1	1				1																		
		S2541		2					2	1																	
		S2542		1					1	1		1															
		S2551			2				17	2		1	2									1					
		S2552		1					16	4		3										1			2		
		S2561							8	1		1	1		1					1							
		S2562			1				8	2	1	1								1							
		S2571		1						1	1	1			1												
		S2572		1					2																		
		S2581			1				8	3					1				1			1					
		S2582			5				1																		
		S2591							6	1					1												
		S2592		1	12				6	3			1			1											

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CUI	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
20 July	15	S1511	2		3				75							32											
		S1512	1		6				108			1			1	24	2										
		S1521	2	2	2		2		138	1	1					39	2					1					
		S1522	1	2	3		1		167		3		1			17	3		1			1					
	20	S2011		7	5	1			35							9			1								
		S2012		4					26	1			1			3											
		S2021			26				22						1	11											
		S2022		1	6				14				1		1	5											
		S2031		9					35	2	1				1	4		1									
		S2032		7					4							2											
	25	S2511	7		6				15				1		1	1						1					
		S2512	1		12		1		10						1							1					
		S2521	2	1					7	1																	
		S2522		1	9				8	1						3		1									
		S2531			1				4																		
		S2532		1	1					2																	
		S2541			1				8									2									
		S2542		1	2				2	1						1											
		S2551							22	2													1				
		S2552		1					12	5													1				
		S2561		2					8										1								
		S2562		2					12			1	1					1									
		S2571							5			1	1		1								1				
		S2572		1					4																		
		S2581		1	1				3	1																	
		S2582		2	1		1		7				2		1				5				2				
		S2591			7				4	1			1														
		S2592			2	1			5										1								

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CUI	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
1 August	15	S1511	5		7		2		72			1		1		19	1	1		1							
		S1512	3		8				74				1	1		24		1									
		S1521		2					128			1	1		1	40			1								
		S1522			2				181			1				22	2										
	20	S2011	2	2	8	2	2		48		1				1	56											
		S2012	41	4	9								1		1	26				1							
		S2021	31		59										1	16											
		S2022	34		38											21											
		S2031	19	1	3					1						1											
		S2032	29	6								1	1			2								1			
	25	S2511		7	6				17	2						1											
		S2512	1	3	2				12	1																	
		S2521	13		8				10			1															
		S2522	9		2								1														
		S2531	9		2						1		1									1					
		S2532	17		4					1	1	1															
		S2541	3		3					1			1							1							
		S2542	1	1	4				1																		
		S2551			1		1		24	1			2														
		S2552	28	2						6	1																
		S2561	19		1					1		2							1	1			2				
		S2562	10									1			1												
		S2571	5	1							1									1							
		S2572	5	1						1	1																
		S2581	10		5											1						1					
		S2582	22	1	6								1			4		1	2								
		S2591	11	1	12							1	1			8											
		S2592	13		27					1													1				

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
17 August	15	S1511	10	1	37				36	1	1					39	1										
		S1512	2		30				34	1			2		1	15											
		S1521	7		1				127					2		16											
		S1522	6		3				139						1	23	2										
	20	S2011	5		10		1									1					1						
		S2012	14		20					1		1				5											
		S2021	8		16										1	8											
		S2022	12		5		1							1	1	3			2								
		S2031	22	1	2		3					1		1													
		S2032	27	1						1		2		1													
	25	S2511	14		5					1						2											
		S2512	9		9					1						2											
		S2521	19		16					1					1	1											
		S2522	23		14					1		1															
		S2531	5				1			1																	
		S2532	2	1	1																		1				
		S2541	4		2										1												
		S2542	4		3		2			2						1											
		S2551	40	2	3		1			4	1					1											
		S2552	54		9					5						21				2							
		S2561	24				1			1									1								
		S2562	16							1																	
		S2571	2	2	1																						
		S2572	6	1																							
		S2581	18	1	12					2																	
		S2582	19	1	5					1																	
		S2591	14		6		1							1		1											
		S2592	12		10																						

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
12 September	15	S1511	14		1				152					1		23	6										
		S1512	20		6				204	2						57											
		S1521	28		3				90	1					1	4											
		S1522	40		6				137	3						51											
	20	S2011	25		9					2	1	1			2	14				1							
		S2012	16		8										1	3											
		S2021	33		73		1								1	29				1							
		S2022	33		61										1	36						1					
		S2031	85		6					1	1					1											
		S2032	60		5					2					1	3											
	25	S2511	5		16									1	1												
		S2512	8		21					1																	
		S2521	12		26										2												
		S2522	20		27					1																	
		S2531	8		12					2					2	3								1			
		S2532	9		22										1	1											
		S2541	4		2					2																	
		S2542	2		4																						
		S2551	24	2																							
		S2552	31	3	1					1							1										
		S2561		14								1	1		1												
		S2562	13								1		1		2												
		S2571	6		1					1			2	1													
		S2572	1	1	2					1				1	3												
		S2581	15		4								1	1		1											
		S2582	34		47										1	26											
		S2591	21		31							1		1		1											
		S2592	22		15		1			1						3											

Table 2c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
12 October	15	S1511	114		2				74	2						35	4										
		S1512	113		5		1		56	3						30	8			1							
		S1521	138	1	2				21	3				2	1	22				1							
		S1522	159						32						1	26	2										
	20	S2011	102		7					1					5	21				2							
		S2012	89		14					1						16											
		S2021	56		19					1						5											
		S2022	62		16					1	1					6											
		S2031	164		4					2					1	35							1				
		S2032	116							1				2		20	1			1							
	25	S2511	30	2	17					1					1												
		S2512	36		13										1												
		S2521	42		19								1	1	1												
		S2522	71		27					1				1													
		S2531	14		8					2					1												
		S2532	14		10				2						1												
		S2541	23		4										1	1											
		S2542	8		19										4	3											
		S2551	28	2																							
		S2552	26	3						1																	
		S2561	11																								
		S2562	14							1						2											
		S2571	13																								
		S2572	10	1																							
		S2581	26		10					1																	
		S2582	38		11									2		1											
		S2591	14		2																						
		S2592	8	1	1					1																	

Table 2c. (concl.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH
7 November	15	S1511	80		1				33	1						21											
		S1512	115		1		1		27	1					1	57	5					1	1		1		
		S1521	83		1		2		50	5	2			1		22											
		S1522	96						35	2				1		18	1								1		
	20	S2011	174		6			1		14			4		2	27									1		1
		S2012	147		10		1			14					1	25											
		S2021	59	4	45					1						15											
		S2022	64	1	81		1			1						11											
		S2031	81	3	12									2	1	6											
		S2032	68	7	14									1	1	4											
	25	S2511	23		19																						
		S2512	18		11										2												
		S2521	24		6										1												
		S2522	18	1	12										1												
		S2531	28		19								4														
		S2532	28		21									1	1												
		S2541	23		9								3		1	1											
		S2542	19		20								1		1												
		S2551	29		2																						
		S2552	9	1																							
		S2561	14																								
		S2562	16													1											
		S2571	11		5									1													
		S2572	8		2									1													
		S2581	8		4											4											
		S2582	10		11										1												
		S2591	73		75								2		1	12				1							1
		S2592	39		30								1	2		7											

Table 2d. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20-, 25-, and 30-m depths (± 2.5 m) in the south basin of Amisk Lake (South Amisk) during 1991. Blanks indicate zero counts. Grab numbers S1511, S1512, S2011, S2012, S2511, and S2512 were collected at the far end of South Amisk, while numbers S1521, S1522, S2021, S2022, S2521 to S2532, and S3011 to S3022 were collected at the near end of South Amisk (Fig. 3.1).

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
6 May	15	S1511	109		8		1	2		3					1	45											
		S1512	122		2		3	1		2						22	1										
	20	S2011	89	5	48			1		3						39											
		S2012	150	7	56	11	3	1		2						144											
		S2021	56	8	8								1			6											
		S2022	27	5	2																						
	25	S2511	56		63			4							1	7											
		S2512	76		46											7											
		S2521	162	4	39		1			2						27											
		S2522	144	2	23			1		5						48											
		S2531	8	2	4																						
		S2532	9		5																						
22 May	15	S1511	86		2		1	1		5						33	1										
		S1512	98		3			1		3				1		41	1										
	20	S2011	48	1	18			1		1					1	1											1
		S2012	29	10	41			1		2						7											
		S2021	92	10	10					2						14			1								
		S2022	84	11	8		1									7											
	25	S2511	18	1	4									1													
		S2512	22		30																						
		S2521	35		4					1																	
		S2522	15		2																						
		S2531	22		2								1		1							1					
		S2532	15	1	3															1							
	30	S3011	14		3																	1					
		S3012	6		1																						

Table 2d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
29 May	15	S1511	81		18		1			3						20	1											
		S1512	113		17					1						56						1						
	20	S2011	65		65											16			1									
		S2012	82	1	74					2					1	4												
		S2021	125	3	2					3						19												
		S2022	111		4		1			1			1			27												
	25	S2511	8		1																							
		S2512	30		28			3																				
		S2521	35		6								1															
		S2522	72	1	5								1															
		S2531	44	2	2					2						1												
		S2532	37	2	3					1						2											1	
13 June	15	S1511	106							3						54	2			1								
		S1512	113		3		1									60												
	20	S2011	93		31	1				2				1		86												
		S2012	66		21					1						47				1					1			
		S2021	73	6	8					2						8											1	
		S2022	71	6	5											12				1								
	25	S2511	18		17											1												
		S2512	15		55											2												
		S2521	24		2					2			1			1												
		S2522	14		1																							

Table 2d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
26 June	15	S1511	78		3		2									68	2	1		1								
		S1512	69		2					2						43	3	1										
	20	S2011	101		51					3					1	20												
		S2012	80		40					2						20									1			
		S2021	106	3	4		1			4						9												
		S2022	60	6			2			1						12				1			1					
	25	S2511	23	1	48																							
		S2512	21		27									1			1											
		S2521	3	1						1																		
		S2522	11																									
	30	S3011	4		2																							
		S3012	1							1																		
10 July	15	S1511	71		2					1	2					54	3											
		S1512	72		1		1	1			1					84	10											
	20	S2011	78		34	1				3						31									2			1
		S2012	115	4	20		1			3	2	1	2			46	1	1	1				1					
		S2021	79		4					1						67							1					
		S2022	85		3					2			1			23							1					
	25	S2511	22		49			1									1											
		S2512	48		54												1											
		S2521	4	1						1			1															
		S2522	7							3																		

Table 2d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
24 July	15	S1511	50		27											33												
		S1512	70		17								1			38							1		1			
	20	S2011	50	2	56					2						26				1					1			
		S2012	50	1	54											15												
		S2021	97	1	9					2		1				20								1				
		S2022	61	1	2						1					31												
	25	S2511	11		24																							
		S2512	14		44								1			1												
		S2521	42	4	2					2																		
		S2522	45	1	1					2			1										2					
	30	S3011	6	2						1					1													
		S3012	16	2						1													1	1				
7 August	15	S1511	75		8				1	1						38												
		S1512	89		24		1									115	3										1	
	20	S2011	66	2	39					3					1	2												
		S2012	51	1	62	1				4						4												
		S2021	79	1	6					3						31												
		S2022	74		9					2						31												
	25	S2511	47		16					1						3												
		S2512	37		11																							
		S2521	19	1											1													
		S2522	5							1																		

Table 2d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
21 August	15	S1511	99		2											31						1						
		S1512	91		6					2				1		45	1											
	20	S2011	64		12					2				2	1	47												
		S2012	79	1	38	1	1			2						36				2								
		S2021	83	1	9					3						17												
		S2022	95		9					2				1		22												
	25	S2511	7	1	11																							
		S2512	35	2	70		1																					
		S2521	9	1	1																							
		S2522	40	11												1												
	30	S3011	1																									
		S3012	1							1																		
7 September	15	S1511	90		4					1						40				1								
		S1512	104		8		1								1	45	1											
	20	S2011	84		26	1				1						36				1								
		S2012	66		28					1				1	2	32												
		S2021	96		6						1			1	1	28												
		S2022	95	1	8		1			1				1		17												
	25	S2511	52		65									1		1												
		S2512	22		52																							
		S2521	11	2												1												
		S2522	10	3												1												

Table 2d. (concl.)

Date	Depth (m)	Grab	ANT	DEC	CU1	CU2	PLU	PUP	IMM	PRO	TAN	ABL	CHI	FLA	PUN	OLI	SPH	GAS	HYA	NEM	TRI	HCA	CER	HIR	HYD	COL	EPH	GAM
17 September	15	S1511	87		1										1	49												
		S1512	100		9		2									53	2						1					
	20	S2011	124		17					1					2	36				1								
		S2012	93		22					1				1	1	63												
		S2021	63		7										1	4												
		S2022	70	1	7					3			1		1	2												
	25	S2511	53		73																							
		S2512	47		29																							
		S2521	5		1																							
		S2522	8	2	1																							
	30	S3011																										
		S3012	2																									
		S3021	2																									
		S3022	1																									
2 October	15	S1511	78		5		1							1		11												
		S1512	114		5										1	22	1											
	20	S2011	43		21	3				2				1		25												
		S2012	39		22	2								2	1	31												
		S2021	50	1	3	1										5												
		S2022	12	1							2			1	5	3												
	25	S2511	46		50																							
		S2512	1		6										1													
		S2521	8							1					1													
		S2522	109	1	3					1																		
	30	S3021	2		1										1													
		S3022	3		1																							
29 October	20	S2011	31		16									2	1	32												
		S2012	63	2	21									4	1	43												
	25	S2511	11		16									1		1												
		S2512	37		57					1																		

Table 3a. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20- and 25- m depths (± 2.5 m) along Transect B1 in the south basin of Baptiste Lake (South Baptiste) during 1988. Blanks indicate zero counts.

Date	Transect	Depth (m)	Grab	ANT	CU2	PLU	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER	GAM
15 May	B1	15	B1W1511		12	9		1		55		21							
			B1W1521	1	2				1	8									
		20	B1W2011							127									
			B1W2021		1	3		1		250									
		25	B1W2511					1		44									1
			B1W2521					1		51									
19 June	B1	15	B1E1511	1	8	11		2		9	13	63							
			B1E1521		21	13		2		13	13	47							
			B1W1511		1	2		8		5	8	4						2	
			B1W1521	1	4	2		2		5	11	9						1	
		20	B1E2011		1	4		1		9	7	1						1	
			B1E2021		2	2		2		7	5								
			B1W2011		1	1		3		12	6				1			1	
			B1W2021			3		4		3	12	1							
		25	B1E2511		1	1		7		13	14								
			B1E2521		1	1		5		7	7								
			B1W2511			2		1		5	11								
			B1W2521					5		14	3								
9 July	B1	15	B1E1511	1	1	11		1		2		28							
			B1E1521		3	8	1	1	1	6		86							
			B1W1511		3	1		1				115							
			B1W1521		1	9		1	2	1		275							
		20	B1E2011			3		2		3									
			B1E2021			1				2	1								
			B1W2011		2	3				2	1								
			B1W2021		2	4		1		2		1							
		25	B1E2511			2		5		5	1							1	
			B1E2521			2		4		5									
			B1W2511			3		4		7									
			B1W2521			1		1		3									
28 July	B1	15	B1E1511		4	14		1		8		36							
			B1E1521		3	6	2	2		5		22							
			B1W1511		7	12		3		3		5			1				
			B1W1521		5	8		1		2									
		20	B1E2011					1		13									
			B1E2021			2				12									
			B1W2011		1	2		4		4									
			B1W2021			1		3		9	2								
		25	B1E2511					2		15									
			B1E2521			1		3		7									
			B1W2511			1		2		11									
			B1W2521					5		29									

Table 3a. (cont.)

Date	Transect	Depth (m)	Grab	ANT	CU2	PLU	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER	GAM
10 August	B1	15	B1E1511		10	5	1	2		4		28							
			B1E1521			5		1				30				1			
			B1W1511	3	4	11		1		11		179	1		1			1	
			B1W1521	4	2	9		5		20	1	187							
		20	B1E2011			3		5		5									
			B1E2021			1		2		8								1	
			B1W2011			2				23									
			B1W2021			1		1	1	12									
		25	B1E2511			3		2		4									
			B1E2521							6									
			B1W2511			2				6		1							
			B1W2521			1		2		6									
25 August	B1	15	B1E1511		1	8		1		90		23							
			B1E1521		1	8				76		21							
			B1W1511		3	6				11		5			1				
			B1W1521	1	1	2		1		10		7							
		20	B1E2011			2		1		47									
			B1E2021		1	3		1		50									
			B1W2011			3		1		6					2				
			B1W2021		1	5		1		7									
		25	B1E2511			1				54		1			3				
			B1E2521							66									
			B1W2511					1		31									
			B1W2521			1		1		18									
11 September	B1	15	B1E1511		11	11	1			35		86							
			B1E1521		9	3				10		41				1			
			B1W1511		15	7		1		49		1			1				
			B1W1521		1	7				48		4						1	
		20	B1E2011		1	5				25									
			B1E2021			1				41		1							
			B1W2011			2				30									
			B1W2021			2				24									
		25	B1E2511							17									
			B1E2521					1		17									
			B1W2511			2				5				1	1				
			B1W2521			1		1		11					1				
9 October	B1	15	B1E1511		1	2				55		17							
			B1E1521		1	1	1			68		16							
			B1W1511		1	1				101		3							
			B1W1521		5	5				57		6							
		20	B1E2011			1				55		1							
			B1E2021							73									
			B1W2011			4				73									
			B1W2021			4			1	69									
		25	B1E2511			1				36									
			B1E2521							43									
			B1W2511			1				34									
			B1W2521							39									

Table 3a. (concl.)

Date	Transect	Depth (m)	Grab	ANT	CU2	PLU	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER	GAM
5 November	B1	15	B1E1511		6	3		1		43		22							
			B1E1521		8	7		2		25		87							
			B1W1511	15	12	2		56		40		32	1		2				
			B1W1521	6	25	3		54		14		21							
		20	B1E2011			1				129									
			B1E2021		1	2				127									
			B1W2011			3				128		1							
			B1W2021							118									
		25	B1E2511			2				51									
			B1E2521		1	1				55									
			B1W2511							59									
			B1W2521							35							1		

Table 3b. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20- and 25- m depths (± 2.5 m) along Transects B1 and B2 in the south basin of Baptiste Lake (South Baptiste) during 1989. Blanks indicate zero counts.

Date	Transect	Depth (m)	Grab	ANT	CU2	PLU	PUP	IMM	PRO	TAN	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER	HIR	HYD
14 May	B1	15	B1E1511	1	23	11			4			84		18								
			B1E1521	1	41	8	1		14			97		81			1	1				
			B1W1511	3	8	10	18		12			11		367			4					
			B1W1521	3	8	4	2		6			17		205			1					
		20	B1E2011									87										
			B1E2021		1	1						67										
			B1W2011			1			1		1	92		4								
			B1W2021			1			2			108					1					
		25	B1E2511									69										
			B1E2521						2		1	64										
			B1W2511									58		1								
			B1W2521									78										
14 May	B2	15	B2E1511	1	1	2			2			71		49			1					
			B2E1521						2			94		12								
			B2W1511			1						38		1								
			B2W1521									24		1								
		20	B2E2011			1						28										
			B2E2021			1			1			31										
			B2W2011									17										
			B2W2021									25										
27 May	B1	15	B1E1511		6	1						6		6								
			B1E1521		7	3						4		2								
			B1W1511	2	6	9			3		2	4		291						1		
			B1W1521	4	2	4			1		1	2		297						1		
		20	B1E2011									20										
			B1E2021									19					1					
			B1W2011			1						49	1	7								
			B1W2021		1	5						32		4								
		25	B1E2511									42					1		1			
			B1E2521									44										
			B1W2511									62										
			B1W2521									52										
27 May	B2	15	B2E1511			1						16		1								
			B2E1521		1	1						23		1								
			B2W1511	1	4	6			1			66		65			1		1			
			B2W1521	1	2	4			2		1	72		65	1			1				1
		20	B2E2011									49										
			B2E2021									63										
			B2W2011									112										
			B2W2021									49										
16 June	B1	15	B1E1511		18	10			2		1	3	3	16						1		
			B1E1521	1	19	7			7			6	2	18								
			B1W1511	8	10	5			3			5	3	317						2		
			B1W1521	7	9	6			1		1	9	3	266								
		20	B1E2011			1						2	3									
			B1E2021			1						12	5									
			B1W2011			2			1			13	7	2								
			B1W2021		1	1			2			11	5									
		25	B1E2511									19	3									
			B1E2521									16	4									
			B1W2511						2			16	2									
			B1W2521						1		1	12	4									
16 June	B2	15	B2E1511		2	2			2			6		22								
			B2E1521			2						7	4	36								
			B2W1511		1				1			118	84				1			1		
			B2W1521		1	1						132	80									
		20	B2E2011									46	19									
			B2E2021						1			57	25									
			B2W2011						1			85	52									
			B2W2021			1						119	54									

Table 3b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	CU2	PLU	PUP	IMM	PRO	TAN	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER	HIR	HYD
30 June	B1	15	B1E1511		22	17			6				4	62						2		
			B1E1521	2	28	14			4			2	3	61						1		
			B1W1511	1	11	3			4			2	5	70						1		
			B1W1521	11	11	3			6			1	1	80								
		20	B1E2011		1				1			7	5									
			B1E2021		1				1			2	5									
			B1W2011						2			1	17									
			B1W2021						4			2	18									
		25	B1E2511		1							2	8									
			B1E2521									2	10									
			B1W2511									1	11									
			B1W2521						1		1	1	18									
30 June	B2	15	B2E1511							1		9	28	2	1							
			B2E1521			3			1			7	42	2						1		
			B2W1511		4	1			1			3	11	8								
			B2W1521			1						5	9	7								
		20	B2E2011									10	5									
			B2E2021						1			5	2									
			B2W2011									7	5									
			B2W2021			1						4	6									
14 July	B1	15	B1E1511	1	17	10								59								
			B1E1521		9	10								21								
			B1W1511	1	6	3			5			1		23			1			1		
			B1W1521	4	4	5			4		1	1		15						2		
		20	B1E2011			3			1													
			B1E2021			1						1										
			B1W2011		1	3			1			1		1			1					
			B1W2021		1	1						1										
		25	B1E2511			1						1	2									
			B1E2521																			
			B1W2511									2	1									
			B1W2521																			
14 July	B2	15	B2E1511		3	2						9	2	12								
			B2E1521		2	3						9	2	10					1			
			B2W1511	1	1	2			2			10		2	1		3	1				1
			B2W1521	1	1							11	3	7	1	2						
		20	B2E2011			2						13	5									
			B2E2021									16	2									
			B2W2011			2						7	4									
			B2W2021			2						7	7						1			
27 July	B1	15	B1E1511		14	4			1		1	10		12								
			B1E1521		13	4						7		25				1				
			B1W1511		7	4			4			19		11	1							
			B1W1521	2	4	2			3			34	1	18								
		20	B1E2011		1	2			1			9										
			B1E2021						2			14										
			B1W2011			1			1			21										
			B1W2021		1	1			2			15	1	1								
		25	B1E2511						1			9										
			B1E2521									11										
			B1W2511									28	1									
			B1W2521									20										
27 July	B2	15	B2E1511									20		3								
			B2E1521			2						14	1						1			
			B2W1511		1	1						7		27	1							
			B2W1521		2	1						11	1	46								
		20	B2E2011									13										
			B2E2021									19	1									
			B2W2011		1	3						19		1								
			B2W2021									10	1									

Table 3b. (cont.)

Date	Transect	Depth (m)	Grab	ANT	CU2	PLU	PUP	IMM	PRO	TAN	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER	HIR	HYD
8 August	B1	15	B1E1511		2	2						88	1	8								
			B1E1521		4	4						66		15								
			B1W1511	2	21	5			2			19		22	1							
			B1W1521	3	20	3			1		1	25		15								
		20	B1E2011			1			2			73										
			B1E2021									41										
			B1W2011		1	1						24							1			
			B1W2021									18										
		25	B1E2511						1			19	1									
			B1E2521									27	1									
			B1W2511									18	2									
			B1W2521									11	1									
8 August	B2	15	B2E1511	1	1	2			2			219		52								
			B2E1521		2	1						160	1	55								
			B2W1511									111		5								
			B2W1521		1	2						74		2								
		20	B2E2011									64		1								
			B2E2021									103										
			B2W2011			1						74	1									
			B2W2021									41										
28 August	B1	15	B1E1511		2	2						51		4						1		
			B1E1521		4	2						61		4								
			B1W1511	1	4	2						160		235								
			B1W1521		1	2						122		7								
		20	B1E2011									41										
			B1E2021						1			28										
			B1W2011		1							44										
			B1W2021		2	1						56										
		25	B1E2511									36										
			B1E2521									36										
			B1W2511									21										
			B1W2521		1							49								1		
28 August	B2	15	B2E1511		3	1						35		36								
			B2E1521									36		50								
			B2W1511									80		14								
			B2W1521									51		7								
		20	B2E2011									16										
			B2E2021									13										
			B2W2011									27						1				
			B2W2021									27										
9 September	B1	15	B1E1511		9	3			1			206		11								
			B1E1521		5	3						109		8								
			B1W1511	3	3	2						203		28			1		1			
			B1W1521	1	1	3						213		15					1	1		
		20	B1E2011									19										
			B1E2021									20										
			B1W2011									62								1		
			B1W2021									66										
		25	B1E2511									35										
			B1E2521									29										
			B1W2511									28										
			B1W2521									34										
9 September	B2	15	B2E1511		2							80		42								
			B2E1521		1	1						51		32								
			B2W1511	18	2							83		42								
			B2W1521	3	1							98		7								
		20	B2E2011									31										
			B2E2021									23										
			B2W2011									38										
			B2W2021									41										

Table 3b. (concl.)

Date	Transect	Depth (m)	Grab	ANT	CU2	PLU	PUP	IMM	PRO	TAN	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER	HIR	HYD
4 October	B1	15	B1E1511		7	6						372		30								
			B1E1521		14	1						350		29								
			B1W1511		4	4			1			267		92					1			
			B1W1521	1	5	3						260		65								
		20	B1E2011									253										
			B1E2021		1	1						198										
			B1W2011		2	2						188										
			B1W2021			1						178										
		25	B1E2511									97										
			B1E2521									110										
			B1W2511									52										
			B1W2521									56										
4 October	B2	15	B2E1511		3	1						277		53								
			B2E1521	4	1							230		122								
			B2W1511			2						404		4	1							
			B2W1521		2	1						333		2								
		20	B2E2011									156		1								
			B2E2021									178										
			B2W2011									112										
			B2W2021									96										
3 November	B1	20	B1E2011		1	1						311										
			B1E2021		1	3						277								1		
			B1W2011									395										
			B1W2021			2						273										
		25	B1E2511									282										
			B1E2521				1					331										
			B1W2511			1						337								1		
			B1W2521			1						321										
3 November	B2	20	B2E2011									107										
			B2E2021									96										
			B2W2011									311			1							

Table 3c. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20- and 25- m depths (± 2.5 m) in the south basin of Baptiste Lake (South Baptiste) during 1990. Blanks indicate zero counts. Grabs marked with '*' were collected with a 523 cm² Ekman dredge.

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER
11 May	15	B1511			11	9		4	1		203		138				2		
		B1512			10	7			1		149		118						
		B1521									29								
		B1522				1		1			16								
	20	B2011			2	1					509		1						
		B2012			1	1					632		1						
		B2021									97								
		B2022									99								
		B2031									106								
		B2032									111								
	25	B2511									505								
		B2512									389								
		B2521									492								
		B2522									497								
		B2531				1					781								
		B2532				1					683								
		B2541									315								
		B2542				1					234								
		B2551									284								
		B2552									205					1			
		B2561									303								
		B2562							2		275								
		B2571									311								
		B2572									284								
		B2581			1						221								
		B2582				1					408								
		B2591									475								
		B2592			1	1			1		457								
29 May	15	B1511			19	8		1			419		85						
		B1512			19	6			2		490		46				1		
		B1521							1		7		3						
		B1522			1					1	7		27			1			
	20	B2011			1						436								
		B2012			2	1					414								
		B2021									12		1						
		B2022							1		20								
		B2031									56								
		B2032									77								
	25	B2511									126								
		B2512									142								
		B2521									113								
		B2522									96								
		B2531									106								
		B2532			1						99								
		B2541									115								
		B2542									120								
		B2551							1		176								
		B2552				2					179								
		B2561							1		165								
		B2562							1		129								
		B2571							1		123								
		B2572									144								
		B2581									152								
		B2582									111								
		B2591				1					196								
		B2592									160						1		

Table 3c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER
15 June	15	B1511*			74	19					298	119	161	2	1	1		2	
		B1512*			68	15			1		318	87	132					1	
		B1521*				1					314	71	1						
		B1522*				3					363	90							
	20	B2011*		1	1						659	160					1		
		B2012*			1	2			1		798	220							
		B2021*									57	25		1					
		B2022*									65	33							
		B2031*									28	3							
		B2032*							1		19	4							
	25	B2511*			1						349	53							
		B2512*				1			2		279	53							
		B2521*				1			1		145	55							
		B2522*			1						136	42							1
		B2531*				3				1	131	34				1			
		B2532*			1	4			2		177	41							
		B2541*							1		164	43							
		B2542*							1		112	27							
		B2551*				1			2		112	31							
		B2552*			1				1		383	72							
27 June	15	B1511			3						5	29							1
		B1512			1	2					11	24	4						
		B1521							1		6	1	1			1			
		B1522									12	9							
	20	B2011			1					1	10	7							
		B2012			2					5	1	4	1					3	
		B2021									2	15							
		B2022			1						1	9							
		B2031									29	48				1			
		B2032							1		38	56							
	25	B2511									12	19							
		B2512									15	30							
		B2521							1		13	33							
		B2522									9	39							
		B2531									21	55							
		B2532									17	90							
		B2541									17	154							
		B2542									30	162							
		B2551									17	96						1	
		B2552				1			1		23	154							
		B2561							1		29	148							
		B2562				1			1	1	48	140							
		B2571									14	51							
		B2572									29	56							
		B2581									21	88							
		B2582				1			1		43	162							
		B2591									44	147							
		B2592				1					40	185							

Table 3c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER
12 July	15	B1511			5	4			1		12		29						
		B1512			1	2			1		11		46						1
		B1521									2	2	1						
		B1522									4	1							
	20	B2011			1				1		20	2							
		B2012			6	1					4		1	1				1	
		B2021				1					5								
		B2022				2					6	2							
		B2031									5	10							
		B2032									3	15							
	25	B2511				1			1		9	3							
		B2512				1			2		12	2							
		B2521									7	5							
		B2522									8	18							
		B2531									17	56							
		B2532									9	2							
		B2541			1						6								
		B2542			1	1					8	3							
		B2551									11	1							
		B2552									4	2							
		B2561									10	7							
		B2562				1					8	1							1
		B2571									8	3							
		B2572									7								
		B2581									8	2							
		B2582									9	6							
		B2591									7	4							
		B2592							1		13	5						1	
23 July	15	B1511			3	8					6	1	27					1	
		B1512			2	2					5		34						1
		B1521									4	1					1		
		B1522									5	2	2						
	20	B2011				1			2		4		11						
		B2012				3					7		7						
		B2021									2	1							
		B2022			1						12								
		B2031									5								
		B2032									4	1							
	25	B2511									5	1						1	
		B2512							1		6	2							
		B2521									6								
		B2522									2	2							
		B2531									3	2							
		B2532									6	12							
		B2541							2		1	2							
		B2542									1	2							
		B2551										1							
		B2552									5	6							
		B2561									9	1							
		B2562									3	3							
		B2571									6								
		B2572									10	1							
		B2581									4	1							
		B2582							1		6	3							
		B2591									7	3							
		B2592									7	10					1		

Table 3c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER
7 August	15	B1511			1	1					19		16						
		B1512			8	3					21		20						
		B1521								1	14							1	
		B1522			1			1			25								
	20	B2011			1	1			1		1								
		B2012			1	1					9								
		B2021									10	1	2						
		B2022				1			1		8								
		B2031									31								
		B2032									60								
	25	B2511									5								
		B2512									2								
		B2521									7								
		B2522									12	2							
		B2531							1		11								
		B2532									16								
		B2541									16	1							
		B2542				1					13								
		B2551									15								
		B2552				1					14								
		B2561				1			1		10	1							
		B2562								1	11						1		
		B2571									31								
		B2572									20								
		B2581									31	1							
		B2582									37								
		B2591									20								
		B2592									25								
20 August	15	B1511			2	1					68		27						1
		B1512			3	2					60		9						
		B1521									88		2					1	
		B1522			2						93								
	20	B2011				2				1	13								
		B2012				1			1		19								
		B2021				2					47								
		B2022				1					34					1			
		B2031									33	1							
		B2032									28								
	25	B2511			1						17								1
		B2512				1					36								
		B2521									14								
		B2522									10								
		B2531									25					1			
		B2532									19					1			
		B2541									22								
		B2542									26								
		B2551				1					33								
		B2552				1					31	1							
		B2561									57					1			
		B2562									30								
		B2571							1		33								
		B2572									25								
		B2581									28	1							
		B2582									61								
		B2591									53								
		B2592									28	1							

Table 3c. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER
14 September	15	B1511			4	2					46		15						
		B1512			4	5				1	66		15						
		B1521									91		1						
		B1522				1					101								
	20	B2011			3						147		8						
		B2012			2	1					153		6						
		B2021			1						59								
		B2022				1					51								
		B2031									65								
		B2032									44								
	25	B2511							1		57								
		B2512				2					46								
		B2521									36							1	
		B2522				1					37								
		B2531									57								
		B2532									82								
		B2541							1		47								
		B2542									73								
		B2551									42								
		B2552									71								
		B2561									33								
		B2562									41								
		B2571									40								
		B2572									55								
		B2581									33								
		B2582									41								
		B2591									36					1			
		B2592									48								
13 October	15	B1511			14	2			3		96		50						
		B1512			9	4		1			143		40						
		B1521				2					148								
		B1522									138								
	20	B2011			1				1		103								
		B2012				1			2		119								
		B2021									109								
		B2022									79								
		B2031									94								
		B2032									80								
	25	B2511				3					93								
		B2512				1					84								
		B2521									81								
		B2522									78								
		B2531									75								
		B2532									107								
		B2541				1					84						1		
		B2542									65								
		B2551									65								
		B2552									81								
		B2561				1					106								
		B2562									83								
		B2571									67								
		B2572									68								
		B2581									109								
		B2582									75								
		B2591									65								
		B2592									98								

Table 3c. (concl.)

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	GAS	HYA	NEM	HCA	CER
8 November	15	B1511			9	1			3		44		42						
		B1512			5	5			2		47		31						
		B1521									227		11						
		B1522			2	1					244		4						
	20	B2011							1		215								
		B2012							1		309								
		B2021									156								
		B2022				1					95								
		B2031									217								
		B2032									241					1			
	25	B2511									128								
		B2512									90								
		B2521									110								
		B2522									146								
		B2531			1						207								
		B2532				1					167								

Table 3d. (cont.)

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	HYA	CER	HIR
28 June	15	B1511			4	1			1	1	3	7	100	1			
		B1512			3	5					5	7	115				
	20	B2011							6		10	5					
		B2012							7		3	3					
		B2021							1		17	11					
		B2022							1		14	12					
	25	B2511							6		14	14					
		B2512				2			2		12	5				1	
		B2521							1		13	4					
		B2522							4		15	9					
8 July	15	B1511			4	2			4		1	1	27				
		B1512			3	3			3		6		47				
	20	B2011			2				2			1					
		B2012			1				3		1	2				1	
		B2021									7	5					
		B2022									8	4					
	25	B2511							2		9	8					
		B2512							2		6	9					
		B2521							3		6	10					
		B2522							3		5	10					
26 July	15	B1511			2	1			2	1	3	1	15				
		B1512			3				3		6		25				
	20	B2011			3				3		2						
		B2012							1		1		1		1		
		B2021							1		6	1	1				
		B2022									3						
	25	B2511				1					2	1					
		B2512							1		4	1					
		B2521							1		3	1					
		B2522									1	1					
8 August	15	B1511			4	1			2		1		8				
		B1512			6	2		1	2		3		110				
		B1513	1		3	4			3		1		202				1
	20	B2011							1		3		5				
		B2012				1					2	1	5				
		B2021									1						
		B2022									2						
	25	B2511							2		3	1					
		B2512									2	1					
		B2521									2	1					
		B2522							1		2	1					

Table 3d. Numbers per grab of macroinvertebrates collected with a 252 cm² Ekman dredge from stations at 15-, 20- and 25- m depths (± 2.5 m) in the south basin of Baptiste Lake (South Baptiste) during 1991. Blanks indicate zero counts.

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	HYA	CER	HIR
9 May	15	B1511			10	4			1		59		81				
		B1512	1		5	6			4		60		94				
	20	B2011							2		246						
		B2012			4				4		133						
		B2021									89		1				
		B2022									111						
	25	B2511							2		162						
		B2512									138						
		B2521				1			1		192						
		B2522									175						
23 May	15	B1511			5				1	1	31		10		1		
		B1512			3	3					27		6				
	20	B2011			1	1			4		43						
		B2012			3						47						
		B2021							1		18						
		B2022			1						19				1		
	25	B2511				1			4		83				1		
		B2512							4	1	103						
		B2521				1			2		67				1		
		B2522							4		113						
31 May	15	B1511			2				1		64		33				
		B1512			4	2			1		43		66		1		
	20	B2011							2		65						
		B2012			2	2			3		82		1				
		B2021									77				1		
		B2022									93						
	25	B2511				1			4		72				1		
		B2512							2		66				1		
		B2521									64						
		B2522							2		103						
14 June	15	B1511			1	1			2	1	5		19				
		B1512			4	1					5	1	56				
	20	B2011							2		17						
		B2012				1			4		13						
		B2021								1	59	11					
		B2022		1					1		53	3					
	25	B2511							1		8	1					
		B2512							1		34	2					1
		B2521							2		43						
		B2522							2		15						

Table 3d. (concl.)

Date	Depth (m)	Grab	ANT	DEC	CU2	PLU	PUP	IMM	PRO	CHI	FLA	FPU	OLI	SPH	HYA	CER	HIR
23 August	15	B1511			7	4					2		118				
		B1512			2	2			1		2		90				
	20	B2011				1					1						
		B2012			2	2					3						
		B2021															
		B2022															
	25	B2511							3		2						
		B2512							1		4						
		B2521							1		1						
		B2522															
8 September	15	B1511				2			1		2		68				
		B1512			3	7					3		109				
	20	B2011			3								1				
		B2012			2						1		1				
		B2021									3		1				
		B2022									4						
	25	B2511															
		B2512								1	2	1					
		B2521							1		3						
		B2522							1		3						
18 September	15	B1511			4	1					10		22				
		B1512			1	1					10		16				
	20	B2011			3						2						
		B2012			1						2						
		B2021									5						
		B2022									3						
	25	B2511									2						
		B2512									4	1					
		B2521									1						
		B2522															
30 October	20	B2011									13		11			1	
		B2012				1				1	12		5				
		B2021									3						
		B2022									4						
	25	B2511									4						
		B2512									1						

Appendix C: Estimated densities·m^{-2} of major taxonomic groups and Chironomus species in North and South Amisk and South Baptiste, 1988-1991.

Table 1. Mean whole-basin densities (no.·m^{-2}) per sampling date of the major taxonomic groups collected during the open water season (May to November) at 15-, 20-, 25-, and 30-m (± 2.5 m) intervals from the north basin of Amisk Lake (North Amisk), 1988-1991. Standard errors are in parentheses. Blanks indicate densities of 0 animals·m^{-2}. '—' indicates that samples were not collected.

1988 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
16 May	15	628.5 (269.8)	14.4 (7.2)	27.5 (16.5)	348.4 (111.2)	16.8 (8.6)	1035.6 (320.3)
	20	186.8 (54.7)	82.6 (69.8)	28.7 (13.2)	25.1 (18.0)	3.6 (3.6)	326.8 (82.8)
	25	43.1 (43.1)	10.8 (15.2)	53.9 (38.3)		21.6 (30.5)	129.3 (89.7)
	30	21.6 (21.6)					21.6 (21.6)
10 June	15	359.2 (143.6)	100.6 (43.0)	82.6 (45.7)	387.9 (107.3)	61.1 (48.3)	790.2 (239.0)
	20	156.2 (20.4)	10.8 (6.2)	21.6 (12.4)	10.8 (6.2)	10.8 (6.2)	210.1 (22.2)
	25	21.6 (0.0)	21.6 (21.6)	10.8 (10.8)			53.9 (10.8)
	30	10.8 (10.8)				10.8 (10.8)	21.6 (21.6)
23 June	15	237.1 (20.1)	111.3 (44.3)	10.8 (7.4)	427.4 (134.4)	21.6 (13.6)	808.1 (171.0)
	20	172.4 (16.7)	21.6 (11.8)	43.1 (16.7)	17.2 (10.6)	4.3 (4.3)	258.6 (22.6)
	25	75.4 (10.8)	21.6 (21.6)	10.8 (10.8)			107.8 (0.0)
	30	10.8 (10.8)	75.4 (32.3)			43.1 (43.1)	129.3 (21.5)
5 July	15	553.1 (107.1)	104.2 (35.8)	14.4 (7.2)	326.8 (64.0)	21.6 (5.6)	1020.0 (180.4)
	20	129.3 (39.1)	51.7 (8.6)	12.9 (8.6)	8.6 (5.3)	17.2 (12.6)	219.8 (31.5)
	25	86.2 (21.6)	43.1 (43.1)				129.3 (64.7)
	30	86.2 (21.6)	43.1 (43.1)				129.3 (64.7)
20 July	15	714.7 (234.7)	143.7 (88.4)	14.4 (7.2)	395.1 (143.7)	21.6 (13.6)	1289.4 (316.8)
	20	202.6 (73.9)	47.4 (23.0)	4.3 (4.3)	43.1 (37.9)	4.3 (4.3)	301.7 (94.2)
	25	75.4 (10.8)	64.7 (21.6)				140.1 (10.8)
	30	10.8 (10.8)	258.6 (0.0)			21.6 (0.0)	290.9 (10.8)
2 August	15	847.6 (280.1)	64.7 922.3)		883.6 (440.8)	10.8 (7.4)	1806.6 (687.8)
	20	224.1 (84.2)	64.7 (13.6)	4.3 (4.3)	51.7 (51.7)	4.3 (4.3)	349.1 (142.0)
	25	118.5 (75.4)					118.5 (75.4)
	30	32.3 (10.8)	290.9 (204.7)			21.6 (0.0)	344.8 (194.0)
18 August	15	1102.6 (727.7)	32.3 (16.5)	75.4 (25.9)	348.4 (162.5)	3.6 (3.6)	1562.4 (900.5)
	20	163.8 (78.5)	34.5 (20.0)	30.2 (16.1)	4.3 (4.3)	4.3 (4.3)	237.1 (85.4)
	25	86.2 (86.2)	75.4 (53.9)				161.6 (140.1)
	30	53.9 (32.3)	21.6 (0.0)				75.4 (32.3)
8 September	15	549.5 (202.8)	7.2 (4.5)	64.7 (12.4)	319.7 (96.9)	7.2 (4.5)	948.2 (299.6)
	20	81.9 (41.7)		47.4 (15.8)	12.9 (12.9)		142.2 (49.9)
	25	86.2 (43.10	10.8 (10.8)	53.9 (10.8)			150.9 (64.7)
	30	75.4 (53.9)	43.1 (21.6)				118.5 (75.4)
7 October	15	1907.2 (1153.3)	28.7 (16.4)	107.8 (39.7)	423.8 (238.7)	10.8 (10.8)	2478.3 (1378.6)
	20	211.2 (78.7)		77.6 (21.1)	34.5 (20.0)		323.3 (117.0)
	25	150.9 (129.3)		21.6 (21.6)			172.4 (150.9)
	30	21.6 (21.6)		43.1 (0.0)			64.7 (21.6)
3 November	15	2797.9 (252.1)	18.0 (6.6)	43.1 (11.1)	704.0 (195.4)	18.0 (14.1)	3580.9 (257.9)
	20	1745.6 (640.1)	8.6 (5.3)	133.6 (40.0)	77.6 (43.4)	17.2 (12.6)	1982.6 (657.3)
	25	355.6 (204.7)	10.8 (10.8)	97.0 (10.8)			463.3 (204.7)
	30	86.2 (0.0)	10.8 (10.8)	53.9 (53.9)		10.8 (10.8)	161.6 (53.9)

Table 1 (cont.)

1989

Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
7 May	15	2521.4 (371.5)	16.2 (5.4)	5.4 (5.4)	872.8 (276.6)	37.7 (25.5)	3453.4 (103.9)
	20	2058.0 (474.8)	5.4 (5.4)	64.7 (37.3)	177.8 (163.7)	10.8 (6.2)	2316.6 (579.8)
	25	215.5 (64.7)		172.4 (21.6)			387.9 (86.2)
25 May	15	1934.1 (451.8)	64.7 (23.3)	37.7 (18.4)	1158.3 (253.7)	53.9 (18.7)	3248.7 (719.2)
	20	1573.2 (202.3)	21.6 98.8)	70.0 (16.2)	16.2 (16.2)	5.4 (5.4)	1686.3 (202.0)
	25	409.5 (64.7)	21.6 (0.0)	183.2 (32.3)		10.8 (10.8)	625.0 (43.10
12 June	15	1853.3 (223.1)	91.6 (30.9)	21.6 (12.4)	1217.6 (134.1)	32.3 (10.8)	3216.3 (368.4)
	20	1357.7 (231.9)	37.7 (25.5)	53.9 (20.6)	53.9 (31.1)	21.6 (12.4)	1524.7 (275.3)
	25	269.4 (247.8)	32.3 (10.8)	64.7 (0.0)	10.8 (10.8)		377.1 (226.3)
23 June	15	1540.8 (278.3)	16.2 (16.2)	10.8 (10.8)	888.9 (221.1)	86.2 (50.5)	2542.9 (485.3)
	20	1179.9 (532.5)	21.6 (15.2)	43.1 (29.2)	431.0 (431.0)	48.5 (18.4)	1724.0 (964.3)
	25	1023.6 (592.6)	10.8 (10.8)	53.9 (53.9)		43.1 (0.0)	1131.4 (549.5)
10 July	15	1465.4 (204.3)	37.7 (18.4)	10.8 (10.8)	969.8 (139.7)	150.9 (57.7)	2634.5 (341.8)
	20	921.3 (197.6)	21.6 (8.8)	21.6 (15.2)	10.8 (10.8)	43.1 (29.2)	1018.2 (222.1)
	25	474.1 (43.1)	32.3 (10.8)			32.3 (10.8)	538.8 (43.1)
20 July	15	1460.0 (209.7)	26.9 (13.6)	10.8 (6.2)	1373.8 (158.5)	145.5 (26.9)	3017.0 (321.4)
	20	1352.3 (390.9)	26.9 (13.6)	10.8 (6.2)	102.4 (82.2)	48.5 (13.6)	1540.8 (469.0)
	25	366.4 (193.9)	10.8 (10.8)			21.6 (0.0)	398.7 (204.7)
3 August	15	1368.4 (244.0)	37.7 (16.2)		969.8 (312.7)	107.8 (8.8)	2483.6 (525.0)
	20	926.7 (360.9)	48.5 (5.4)	5.4 (5.4)	226.3 (198.0)	43.1 (23.3)	1249.9 (554.5)
	25	851.2 (614.2)	43.1 (21.6)		21.6 (0.0)	21.6 (0.0)	937.4 (635.7)
21 August	15	899.7 (226.9)	26.9 (10.3)	48.5 (10.3)	1212.2 (676.4)	97.0 (43.5)	2284.3 (917.6)
	20	765.0 (438.2)	59.3 (25.5)	64.7 (12.4)	32.3 (18.7)	53.9 (18.7)	975.1 (425.1)
	25	215.5 (64.7)	21.6 (21.6)			10.8 (10.8)	247.8 (97.0)
7 September	15	576.5 (185.0)	5.4 (5.4)	26.9 (10.3)	447.2 (88.1)	37.7 (16.2)	1093.7 (264.6)
	20	226.3 (177.4)	5.4 (5.4)	16.2 (10.3)	70.0 (63.1)	5.4 (5.4)	323.3 (238.5)
	25	150.9 (129.3)	21.6 (0.0)		10.8 (10.8)	10.8 (10.8)	194.0 (129.3)
1 October	15	759.6 (216.3)	5.4 (5.4)	37.7 (18.4)	468.7 (181.9)	48.5 (5.4)	1319.9 (389.1)
	20	269.4 (240.9)		64.7 (38.3)	32.3 (32.3)		366.4 (262.3)
	25	172.4 (86.2)		32.3 (10.8)			204.7 (97.0)
31 October	15	—	—	—	—	—	—
	20	1697.1 (701.0)	5.4 (5.4)	75.4 (41.7)	253.2 (189.2)	48.5 (16.2)	2079.6 (739.1)
	25	689.6 (431.0)	10.8 (10.8)	97.0 (53.9)		21.6 (0.0)	818.9 (366.4)

Table 1 (cont.)

1990 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
9 May	15	1120.6 (215.5)	107.8 (43.1)	21.6 (0.0)	657.3 (75.4)		1907.2 (97.0)
	20	969.8 (162.7)	28.7 (19.0)	93.4 (19.0)	7.2 (7.2)		1099.1 (176.4)
	25	206.9 (32.4)	25.9 (10.6)	81.9 (18.5)		8.6 (5.3)	323.3 (45.2)
26 May	15	711.2 (150.8)	64.7 (64.7)	75.4 (10.8)	1196.0 (312.5)	53.9 (32.3)	2101.1 (183.2)
	20	668.1 (149.3)	50.3 (14.4)	64.7 (12.4)	107.8 (87.1)	21.6 (12.4)	912.3 (63.8)
	25	237.1 (90.7)	73.3 (17.5)	125.0 (37.0)	17.2 (10.6)	17.2 (8.1)	469.8 (105.0)
11 June	15	1314.6 (581.9)	183.2 (53.9)	43.1 (43.1)	1045.2 (377.1)	64.7 (43.1)	2650.7 (150.9)
	20	431.0 (64.7)	50.3 (14.4)	43.1 (0.0)	21.6 (12.4)	21.6 (12.4)	567.5 (82.8)
	25	245.7 (80.5)	60.3 (19.8)	38.8 (24.0)		8.6 (5.3)	353.4 (57.3)
22 June	15	312.5 (140.1)	21.6 (0.0)	21.6 (21.6)	323.3 (215.5)	21.6 (21.6)	700.4 (75.4)
	20	294.5 (38.0)	43.1 (21.6)	14.4 (14.4)		21.6 (0.0)	373.5 (25.9)
	25	142.2 (37.7)	17.2 (8.1)	12.9 (5.3)		8.6 (5.3)	181.0 (37.7)
10 July	15	1627.0 (657.3)	32.3 (10.8)		431.0 (21.6)	43.1 (21.6)	2133.5 (625.0)
	20	912.3 (230.2)	57.5 (31.3)	14.4 (7.2)	64.7 (44.9)	64.7 (32.9)	1113.4 (234.9)
	25	620.6 (121.8)	81.9 (14.3)	8.6 (5.3)	8.6 (8.6)	34.5 (14.6)	754.3 (130.2)
19 July	15	2564.5 (991.3)	43.1 (43.1)	10.8 (10.8)	969.8 (517.2)	10.8 (10.8)	3598.9 (1530.1)
	20	1515.7 (612.4)	43.1 (21.6)		57.5 (35.9)	57.5 (7.2)	1673.7 (646.5)
	25	913.7 (246.0)	81.9 (26.7)	12.9 (8.6)	34.5 (22.2)	73.3 (18.8)	1116.3 (302.4)
3 August	15	1260.7 (269.4)	32.3 (10.8)		797.4 (409.4)	32.3 (10.8)	2122.7 (657.3)
	20	2621.9 (1630.7)	21.6 (12.4)	7.2 (7.2)	122.1 (82.8)	28.7 (14.4)	2801.5 (1618.0)
	25	931.0 (250.8)	25.9 (15.8)	4.3 (4.3)	25.9 (8.1)	56.0 (17.5)	1043.0 (279.8)
16 August	15	1540.8 (140.1)	32.3 (10.8)	32.3 (32.3)	387.9 (21.6)	86.2 (43.1)	2079.6 (161.6)
	20	1817.4 (971.9)	21.6 (0.0)	43.1 (0.0)	43.1 (21.6)	28.7 (7.2)	1953.9 (947.7)
	25	1189.6 (361.1)	12.9 (8.6)	4.3 (4.3)	30.2 (16.1)	21.6 (11.8)	1258.5 (386.0)
11 September	15	2553.7 (1152.9)	21.6 (21.6)	129.3 (43.1)	926.7 (0.0)	43.1 (0.0)	3674.3 (1174.5)
	20	1803.0 (716.9)	28.7 (19.0)	86.2 (21.6)	79.0 (79.0)	43.1 (12.6)	2040.1 (679.9)
	25	1060.3 (309.9)	30.2 (11.0)	56.0 (24.2)		12.9 (8.6)	1159.4 (313.7)
11 October	15	1928.7 (290.9)	129.3 (64.7)	75.4 (53.9)	937.4 (247.8)	75.4 (53.9)	3146.3 (86.2)
	20	3505.5 (1573.0)	57.5 (35.9)	194.0 (87.1)	21.6 (12.4)		3778.4 (1528.8)
	25	1918.0 (589.3)	25.9 (15.8)	77.6 (17.5)	4.3 (4.3)	8.6 (8.6)	2034.3 (614.5)
6 November	15	2370.5 (495.7)	377.1 (204.7)	97.0 (75.4)	1562.4 (118.5)	53.9 (53.9)	4460.9 (797.4)
	20	4037.0 (888.7)	143.7 (19.0)	64.7 (32.9)	337.6 (150.5)	114.9 (61.4)	4697.9 (699.3)
	25	3021.3 (878.4)	77.6 (24.2)	86.2 (20.4)	4.3 (4.3)	34.5 (11.0)	3223.9 (890.7)

Table 1 (concl.)

1991 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
6 May	15	2284.3 (129.3)	603.4 (258.6)		1034.4 (258.6)	21.6 (21.6)	3943.7 (150.8)
	20	2973.9 (1422.3)	280.2 (280.2)	64.7 (21.6)	420.2 (420.2)	21.6 (0.0)	3760.5 (2101.1)
	25	2219.7 (703.7)	28.7 (14.4)	35.9 (14.4)	21.6 (12.4)	7.2 (7.2)	2313.0 (700.8)
21 May	15	1314.6 (21.6)	323.3 (237.1)	43.1 (43.1)	2155.0 (0.0)	21.6 (21.6)	3857.5 (280.2)
	20	3178.6 (1131.4)	86.2 (86.2)	64.7 (43.1)	53.9 (53.9)		3383.4 (1228.4)
	25	3261.2 (1368.3)	79.0 (47.1)	21.6 (0.0)	114.9 (104.3)	14.4 (7.2)	3491.1 (1518.5)
	30	1788.7 (237.0)	107.8 (21.6)	86.2 (43.1)		21.6 (21.6)	2004.2 (323.3)
28 May	15	1896.4 (43.1)	323.3 (107.8)	43.1 (0.0)	2068.8 (215.5)	21.6 (21.6)	4353.1 (387.9)
	20	4094.5 (1120.6)	53.9 (10.8)	86.2 (0.0)	32.3 (32.3)		4266.9 (1142.2)
	25	3131.9 (1592.1)	57.5 (7.2)	35.9 (25.9)	7.2 (7.2)	14.4 (14.4)	3246.9 (1567.2)
11 June	15	1400.8 (21.5)	64.7 (21.6)	21.6 (21.6)	2801.5 (689.6)	64.7 (21.6)	4353.1 (732.7)
	20	1795.8 (147.3)	100.6 (46.7)	7.2 (3.6)	0.0 (431.0)	21.6 (10.8)	1925.1 (229.9)
	25	1838.9 (887.9)	114.9 (19.0)	35.9 (19.0)	64.7 (44.9)	35.9 (19.0)	2090.4 (890.6)
25 June	15	1034.4 (86.2)	86.2 (86.2)	21.6 (21.6)	1357.7 (797.4)		2499.8 (775.8)
	20	3189.4 (668.1)	86.2 (21.6)	21.6 (21.6)	10.8 (10.8)	10.8 (10.8)	3318.7 (711.2)
	25	2661.4 (1196.0)	86.2 (64.7)	21.6 (0.0)		53.9 (53.9)	2823.1 (1077.5)
	30	1185.3 (194.0)	64.7 (21.6)				1249.9 (215.5)
9 July	15	2111.9 (215.5)	43.1 (0.0)		2435.2 (711.2)		4590.2 (926.7)
	20	2973.9 (1034.4)	53.9 (53.9)	21.6 (0.0)	1928.7 (1907.2)	10.8 (10.8)	4988.8 (2984.7)
	25	3070.9 (2101.1)	150.9 (129.3)	32.3 (10.8)	86.2 (86.2)	118.5 (118.5)	3458.8 (2424.4)
23 July	15	1465.4 (258.6)	21.6 (21.6)	43.1 (43.1)	2370.5 (1336.1)	64.7 (64.7)	3965.2 (1594.7)
	20	2672.2 (1443.9)	53.9 (32.3)		754.3 (732.7)	86.2 (21.6)	3566.5 (2187.3)
	25	2122.7 (1454.6)	75.4 (53.9)		53.9 (53.9)	10.8 (10.8)	2262.8 (1573.2)
	30	323.3 (21.6)	21.6 (21.6)				344.8 (43.1)
6 August	15	2887.7 (344.8)	43.1 (0.0)		2499.8 (387.9)		5430.6 (732.7)
	20	2068.8 (1508.5)	53.9 (53.9)	10.8 (10.8)	97.0 (97.0)	43.1 (0.0)	2273.5 (1648.6)
	25	1724.0 (1271.5)	43.1 (21.6)			107.8 (86.2)	1874.9 (1379.2)
20 August	15	1702.5 (237.0)		43.1 (43.1)	2758.4 (1379.2)		4504.0 (1099.1)
	20	2930.8 (1314.6)	64.7 (64.7)		21.6 (0.0)	32.3 (10.8)	3049.3 (1368.4)
	25	2230.4 (1519.3)	107.8 (21.6)		53.9 (53.9)	53.9 (53.9)	2445.9 (1648.6)
	30	2542.9 (301.7)	64.7 (21.6)			43.1 (43.1)	2650.7 (323.3)
6 September	15	1142.2 (323.3)		107.8 (21.6)	2844.6 (991.3)		4094.5 (689.6)
	20	2532.1 (1540.3)	10.8 (10.8)	64.7 (0.0)	21.6 (21.6)	21.6 (0.0)	2650.7 (1573.2)
	25	1885.6 (1390.0)	32.3 (10.8)	10.8 (10.8)	53.9 (53.9)		1982.6 (1422.3)
17 September	15	1142.2 (150.8)			1314.6 (797.4)		2456.7 (948.2)
	20	2456.7 (905.1)	43.1 (43.1)	75.4 (75.4)	10.8 (10.8)	53.9 (10.8)	2639.9 (872.8)
	25	1573.2 (1357.7)	10.8 (10.8)	21.6 (21.6)	10.8 (10.8)	10.8 (10.8)	1627.0 (1346.9)
	30	86.2 (0.0)	43.1 (0.0)				129.3 (0.0)
1 October	15	1745.6 (1271.5)		86.2 (43.1)	5258.2 (4568.6)		7090.0 (5797.0)
	20	2144.2 (420.2)	10.8 (10.8)	86.2 (21.6)	10.8 (10.8)	21.6 (0.0)	2273.5 (420.2)
	25	1828.2 (1548.0)	14.4 (14.4)	14.4 (14.4)	43.1 (43.1)		1900.0 (1619.8)
29 October	15	—	—	—	—	—	—
	20	3189.4 (258.6)		21.6 (21.6)		43.1 (43.1)	3254.1 (237.0)
	25	3232.5 (474.1)			64.7 (21.6)	21.6 (21.6)	3318.7 (517.2)

Table 2a. Mean whole-basin densities (no.·m^{-2}) per sampling date of the major taxonomic groups collected during the open water season (May to November) at 15-, 20-, 25-, and 30-m (± 2.5 m) intervals from the south basin of Amisk Lake (South Amisk), 1988-1991. Standard errors are in parentheses. Blanks indicate densities of 0 animals·m^{-2}. '—' indicates that samples were not collected.

1988 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
25 May	15	226.3 (53.9)	107.8 (43.1)		1303.8 (53.9)	10.8 (10.8)	1648.6 (53.9)
	20	312.5 (161.6)		32.3 (10.8)	614.2 (549.5)		959.0 (700.4)
	25	43.1 (0.0)	21.6 (21.6)	10.8 (10.8)	75.4 (32.3)		150.9 (64.7)
	30			10.8 (21.6)		10.8 (21.6)	21.6 (43.1)
13 June	15	323.3 (194.0)	150.9 (107.8)	10.8 (10.8)	1530.1 (797.4)	43.1 (43.1)	2058.0 (1131.4)
	20	118.5 (10.8)	43.1 (21.6)	10.8 (10.8)	581.9 (452.6)	10.8 (10.8)	765.0 (506.4)
	25	118.5 (75.4)	43.1 (43.1)	21.6 (21.6)	118.5 (118.5)	43.1 (21.6)	344.8 (280.2)
	30	64.7 (21.6)	21.6 (21.6)	43.1 (43.1)		21.6 (21.6)	75.4 (64.7)
28 June	15	183.2 (75.4)	194.0 (21.6)	10.8 (10.8)	1745.6 (64.6)	53.9 (32.3)	2187.3 (183.2)
	20	150.9 (86.2)	32.3 (32.3)		161.6 (118.5)	10.8 (10.8)	355.6 (53.9)
	25	75.4 (10.8)	75.4 (32.3)		64.7 (21.6)		215.5 (43.1)
	30	32.3 (10.8)	53.9 (32.3)			10.8 (10.8)	97.0 (32.3)
12 July	15	969.8 (495.7)	118.5 (97.0)		732.7 (172.4)	10.8 (10.8)	1831.8 (775.8)
	20	226.3 (97.0)	53.9 (10.8)		1109.8 (140.1)		1390.0 (226.3)
	25	64.7 (43.1)	32.3 (10.8)		32.3 (32.3)		129.3 (86.2)
	30	21.6 (0.0)		10.8 (10.8)		10.8 (10.8)	43.1 (0.0)
26 July	15	2963.1 (614.2)	247.8 (97.0)		2790.7 (10.8)	97.0 (75.4)	6098.7 (775.8)
	20	172.4 (43.1)	97.0 (97.0)		959.0 (851.2)		1228.4 (991.3)
	25	32.3 (32.3)	10.8 (10.8)				43.1 (21.6)
	30	10.8 (10.8)			10.8 (10.8)		21.6 (0.0)
4 August	15	678.8 (398.7)	140.1 (32.3)		560.3 (172.4)	10.8 (10.8)	1390.0 (549.5)
	20	495.7 (280.2)	21.6 (21.6)		592.6 (161.6)	10.8 (10.8)	1120.6 (452.6)
	25	32.3 (10.8)		10.8 (10.8)	97.0 (97.0)		140.1 (118.5)
	30						
24 August	15	2316.6 (377.1)	64.7 (21.6)	75.4 (32.3)	1508.5 (43.1)	64.7 (64.7)	4029.9 (280.1)
	20	75.4 (32.3)		43.1 (21.6)	398.7 (312.5)	32.3 932.3)	549.5 (398.7)
	25	97.0 (32.3)	10.8 (10.8)	10.8 (10.8)	53.9 (32.3)	21.6 (21.6)	194.0 (21.6)
	30			32.3 (32.3)		10.8 (10.8)	43.1 (43.1)
9 September	15	2639.9 (334.0)	32.3 (32.3)	43.1 (43.1)	1540.8 (226.3)	64.7 (43.1)	4320.8 (140.1)
	20	194.0 (129.3)	21.6 (0.0)	43.1 (0.0)	1131.4 (183.2)	10.8 (10.8)	1400.8 (43.1)
	25	86.2 (64.7)	21.6 (0.0)	43.1 (43.1)	64.7 (0.0)	10.8 (10.8)	226.3 (97.0)
	30		10.8 (10.8)				10.8 (10.8)
8 October	15	1400.8 (668.1)	32.3 (10.8)		1745.6 (409.4)	10.8 (10.8)	3189.4 (1099.1)
	20	398.7 (269.4)	21.6 (21.6)	43.1 (21.6)	1756.3 (1174.5)	10.8 (10.8)	2230.4 (1454.6)
	25	129.3 (21.6)		32.3 (10.8)	107.8 (43.1)		269.4 (53.9)
	30			10.8 (10.8)			10.8 (10.8)
4 November	15	3501.9 (1002.1)	86.2 (0.0)	43.1 (43.1)	2553.7 (1023.6)	334.0 (269.4)	6518.9 (1713.2)
	20	409.5 (43.1)		53.9 (10.8)	312.5 (247.8)		775.8 (215.5)
	25	398.7 (75.4)		32.3 (10.8)	97.0 (53.9)		528.0 (118.5)
	30	32.3 (32.3)		10.8 (10.8)			43.1 (21.6)

Table 2a. (cont.)

1989

Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
12 May	15	3275.6 (329.5)	59.3 (28.3)	10.8 (6.2)	1562.4 (238.4)	16.2 (10.3)	4924.2 (460.4)
	20	334.0 (114.9)	5.4 (5.4)	26.9 (10.3)	75.4 (48.6)		441.8 (161.6)
	25	10.8 (10.8)	10.8 (10.8)				21.6 (0.0)
26 May	15	2602.2 (276.4)	123.9 (67.8)	10.8 (6.2)	1939.5 (255.7)	107.8 (41.3)	4784.1 (608.6)
	20	721.9 (185.9)	26.9 (5.4)	10.8 (10.8)	592.6 (343.2)	10.8 (6.2)	1363.0 (320.8)
	25	43.1 (43.1)	21.6 (0.0)		21.6 (21.6)	10.8 (10.8)	97.0 (75.4)
14 June	15	2801.5 (454.9)	91.6 (51.6)		1794.0 (272.9)	118.5 (56.7)	4805.7 (645.2)
	20	1115.2 (616.1)	10.8 (6.2)	16.2 (10.3)	619.6 (330.3)	16.2 (5.4)	1777.9 (887.3)
	25	64.7 (0.0)	10.8 (10.8)			10.8 (10.8)	86.2 (21.6)
24 June	15	2839.2 (278.0)	64.7 (43.1)	5.4 (5.4)	1761.7 (393.9)	97.0 (35.7)	4767.9 (609.7)
	20	603.4 (134.3)	43.1 (30.5)	5.4 (5.4)	172.4 (66.4)	59.3 (29.7)	883.6 (202.3)
	25	32.3 (10.8)	10.8 (10.8)			21.6 (0.0)	64.7 (21.6)
12 July	15	2128.1 (166.3)	43.1 (23.3)	10.8 (6.2)	1470.8 (259.4)	140.1 (35.7)	3792.8 (347.8)
	20	630.3 (91.6)	37.7 (22.2)	16.2 (5.4)	366.4 (175.3)	26.9 (20.4)	1077.5 (268.4)
	25	21.6 (21.6)	21.6 (21.6)			10.8 (10.8)	53.9 (53.9)
21 July	15	2036.5 (172.1)	48.5 (18.4)		1713.2 (203.2)	156.2 (28.3)	3954.4 (333.9)
	20	1395.4 (341.6)	48.5 (18.4)		1104.4 (453.4)	53.9 (25.6)	2602.2 (795.7)
	25	161.6 (75.4)	43.1 (43.1)	10.8 (10.8)	21.6 (21.6)	64.7 (0.0)	301.7 (43.1)
4 August	15	2063.4 (288.0)	48.5 (28.3)	21.6 (8.8)	1249.9 (410.5)	86.2 (45.7)	3469.6 (681.2)
	20	1012.9 (275.8)	64.7 (31.7)	5.4 (5.4)	678.8 (471.4)	10.8 (10.8)	1772.5 (737.5)
	25	86.2 (64.7)	10.8 (10.8)				97.0 (75.4)
23 August	15	1594.7 (368.8)	32.3 (25.6)	64.7 (23.3)	932.0 (496.5)	59.3 (29.7)	2683.0 (692.1)
	20	498.4 (175.6)	37.7 (25.5)	21.6 (7.6)	220.9 (142.5)	5.4 (5.4)	754.3 (346.9)
	25	183.2 (161.6)		10.8 (10.8)	10.8 (10.8)	32.3 (32.3)	237.1 (194.0)
8 September	15	1018.2 (192.4)		53.9 (10.8)	689.6 (305.7)	21.6 (8.8)	1783.3 (292.0)
	20	425.6 (196.6)		32.3 (10.8)	134.7 (85.5)	5.4 (5.4)	598.0 (259.3)
	25	43.1 (43.1)		32.3 (32.3)		10.8 (10.8)	86.2 (86.2)
2 October	15	1783.3 (231.5)	5.4 (5.4)	86.2 (23.3)	835.1 (209.9)	21.6 (12.4)	2731.5 (440.2)
	20	436.4 (140.3)	5.4 (5.4)	32.3 (10.8)	371.7 (195.2)	10.8 (6.2)	856.6 (327.0)
	25	290.9 (183.2)		64.7 (43.1)	64.7 (64.7)	10.8 (10.8)	431.0 (215.5)
31 October	15	—	—	—	—	—	—
	20	603.4 (235.1)	10.8 (6.2)	80.8 (35.6)	371.7 (132.4)	5.4 (5.4)	1072.1 (330.5)
	25			32.3 (32.3)			32.3 (32.3)

Table 2a. (cont.)

1990 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
10 May	15	1185.3 (387.9)	53.9 (53.9)	10.8 (10.8)	1325.3 (571.1)	64.7 (0.0)	2639.9 (140.1)
	20	466.9 (348.9)	7.2 (8.8)	7.2 (0.0)	194.0 (35.2)	7.2 (8.8)	682.4 (500.2)
	25	69.4 (19.6)	4.8 (3.2)	23.9 (7.6)	4.8 (3.2)	2.4 (2.4)	105.4 (22.6)
27 May	15	377.1 (10.8)	64.7 (43.1)	43.1 (0.0)	1562.4 (398.7)	64.7 (43.1)	2111.9 (474.1)
	20	488.5 (201.1)	43.1 (35.2)	43.1 (8.8)	373.5 (316.7)	7.2 (8.8)	955.4 (451.6)
	25	47.9 (14.7)	33.5 (7.3)	23.9 (9.1)	4.8 (3.2)	12.0 (6.3)	122.1 (25.1)
14 June	15	284.7 (103.2)	62.1 (62.1)	9.6 (9.6)	1368.0 (269.8)	23.9 (23.9)	1748.2 (277.5)
	20	110.7 (23.7)	19.9 (7.8)	12.7 (7.8)	227.7 (3.9)	26.3 (7.8)	397.3 (124.0)
	25	52.4 (15.8)	54.2 (9.5)	11.7 (3.3)	7.7 (5.5)	39.1 (9.5)	165.1 (20.1)
26 June	15	290.9 (97.0)		10.8 (10.8)	883.6 (0.0)	53.9 (53.9)	1239.1 (140.1)
	20	265.8 (143.1)	28.7 (0.0)	7.2 (8.8)	337.6 (158.4)	7.2 (8.8)	646.5 (260.7)
	25	83.8 (41.5)	16.8 (10.0)	12.0 (5.2)	81.4 (53.4)	16.8 (7.0)	210.7 (90.1)
11 July	15	3749.7 (797.4)	194.0 (86.2)	21.6 (21.6)	1303.8 (377.1)	107.8 (64.7)	5376.7 (549.5)
	20	632.1 (158.5)	43.1 (35.2)	7.2 (8.8)	337.6 (17.6)	57.5 (17.6)	1077.5 (143.5)
	25	342.4 (79.1)	93.4 (24.6)	12.0 (3.8)	2.4 (2.4)	23.9 (9.8)	474.1 (106.4)
20 July	15	5549.1 (1346.9)	75.4 (53.9)	10.8 (10.8)	1206.8 (0.0)	107.8 (64.7)	6949.9 (1454.6)
	20	1451.0 (144.2)	43.1 (17.6)	21.6 (8.8)	244.2 (88.0)	14.4 (8.8)	1774.3 (178.7)
	25	490.9 (101.0)	52.7 (13.0)	9.6 (5.2)	12.0 (7.3)	43.1 (14.4)	608.2 (110.3)
1 August	15	5215.1 (1530.1)	53.9 (10.8)	32.3 (10.8)	1131.4 (204.7)	75.4 (10.8)	6508.1 (1724.0)
	20	2428.0 (649.5)	35.9 (26.4)	21.6 (8.8)	876.4 (299.1)	14.4 (8.8)	3376.2 (988.2)
	25	816.5 (128.3)	79.0 (19.0)	2.4 (2.4)	33.5 (21.0)	28.7 (11.4)	960.2 (145.9)
17 August	15	4665.6 (1433.1)	53.9 (53.9)	43.1 (21.6)	1002.1 (161.6)	32.3 (10.8)	5797.0 (1249.9)
	20	1063.1 (87.4)	43.1 (35.2)	35.9 (8.8)	122.1 (96.8)	21.6 (17.6)	1285.8 (25.9)
	25	945.8 (230.4)	55.1 (21.6)	7.2 (3.6)	69.4 (51.4)	9.6 (5.2)	1087.1 (294.2)
12 September	15	7553.3 (1002.1)	64.7 (21.6)	21.6 (0.0)	1454.6 (269.4)	64.7 (64.7)	9158.8 (1314.6)
	20	2981.1 (909.7)	57.5 (35.2)	43.1 (8.8)	617.8 (536.7)	21.6 (17.6)	3721.0 (1166.2)
	25	1166.1 (238.1)	43.1 (8.8)	43.1 (11.4)	83.8 (63.5)	4.8 (3.2)	1340.9 (271.9)
12 October	15	7736.5 (129.3)	86.2 (21.6)	43.1 (43.1)	1217.6 (183.2)	172.4 (107.8)	9255.7 (398.7)
	20	4662.0 (816.3)	57.5 (0.0)	57.5 (26.4)	739.9 (387.1)	35.9 (26.4)	5552.7 (1126.0)
	25	1384.0 (316.9)	21.6 (5.1)	33.5 (12.5)	16.8 (10.0)		1455.8 (324.3)
7 November	15	5656.9 (97.0)	118.5 (75.4)	32.3 (10.8)	1271.5 (409.5)	107.8 (64.7)	7186.9 (290.9)
	20	5595.8 (959.3)	244.2 (17.6)	57.5 (44.0)	632.1 (140.8)	14.4 (0.0)	6544.0 (1435.8)
	25	1546.8 (425.6)	26.3 (13.3)	33.5 (7.3)	59.9 (44.7)	4.8 (4.8)	1671.3 (482.3)

Table 2a. (concl.)

1991 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
6 May	15	5344.4 (172.4)	107.8 (21.6)	21.6 (21.6)	1443.9 (495.7)	21.6 (21.6)	6939.1 (344.8)
	20	5139.7 (2855.4)	64.7 (43.1)		2036.5 (1907.2)		7240.8 (4805.7)
	25	4662.0 (2186.8)	50.3 (50.3)	7.2 (7.2)	639.3 (496.2)		5358.8 (2677.8)
22 May	15	4137.6 (258.6)	172.4 (43.1)	21.6 (21.6)	1594.7 (172.4)	43.1 (0.0)	5969.4 (409.4)
	20	3932.9 (721.9)	53.9 (10.8)	10.8 (10.8)	312.5 (140.1)	21.6 (0.0)	4331.6 (840.5)
	25	1249.9 (200.2)	14.4 (7.2)	14.4 (7.2)		14.4 (14.4)	1293.0 (183.3)
	30	517.2 (215.5)				21.6 (21.6)	538.8 (237.1)
29 May	15	4956.5 (646.5)	86.2 (43.1)		1637.8 (775.8)	43.1 (0.0)	6723.6 (1379.2)
	20	5743.1 (441.8)	75.4 (32.3)	10.8 (10.8)	711.2 (280.2)	10.8 (10.8)	6551.2 (150.8)
	25	2004.2 (306.5)	35.9 (19.0)		21.6 (21.6)	7.2 (7.2)	2068.8 (317.5)
13 June	15	4805.7 (237.0)	64.7 (64.7)		2456.7 (129.3)	64.7 (64.7)	7391.7 (237.0)
	20	4105.3 (463.3)	53.9 (10.8)	10.8 (10.8)	1648.6 (1217.6)	43.1 (0.0)	5861.6 (1702.5)
	25	1573.2 (689.6)	32.3 (32.3)		43.1 (21.6)		1648.6 (678.8)
26 June	15	3318.7 (258.6)	43.1 (43.1)		2392.1 (538.8)	172.4 (0.0)	5926.3 (754.3)
	20	4891.9 (969.8)	107.8 (0.0)	10.8 (10.8)	657.3 (204.7)	32.3 (10.8)	5700.0 (1174.5)
	25	1454.6 (1131.4)	10.8 (10.8)	10.8 (10.8)		10.8 (10.8)	1487.0 (1142.2)
	30	150.9 (107.8)	21.6 (21.6)				172.4 (86.2)
10 July	15	3189.4 (43.1)	86.2 (43.1)		2973.9 (646.5)	280.2 (150.9)	6529.7 (797.4)
	20	4568.6 (883.5)	161.6 (75.4)		1799.4 (140.1)	97.0 (53.9)	6626.6 (872.8)
	25	2004.2 (1745.6)	53.9 (53.9)			21.6 (21.6)	2079.6 (1713.2)
24 July	15	3534.2 (215.5)	21.6 (21.6)		1530.1 (107.8)	43.1 (43.1)	5128.9 (387.9)
	20	4137.6 (452.6)	64.7 (21.6)		991.3 (107.8)	32.3 (10.8)	5225.9 (334.0)
	25	2025.7 (21.6)	64.7 (43.1)		10.8 (10.8)	21.6 (21.6)	2122.7 (75.4)
	30	560.3 (215.5)	43.1 (0.0)	21.6 (21.6)		43.1 (43.1)	668.1 (237.1)
7 August	15	4266.9 (646.5)	21.6 (21.6)		3297.2 (1659.4)	86.2 (86.2)	7671.8 (2370.5)
	20	4213.0 (571.1)	129.3 (21.6)	10.8 (10.8)	732.7 (603.4)		5085.8 (0.0)
	25	1465.4 (926.7)	21.6 (0.0)	10.8 (10.8)	32.3 (32.3)		1530.1 (948.2)
21 August	15	4266.9 (86.2)	43.1 (43.1)	21.6 (21.6)	1637.8 (301.7)	43.1 (0.0)	6012.5 (280.2)
	20	4234.6 (10.8)	97.0 (10.8)	43.1 (21.6)	1314.6 (474.1)	21.6 (21.6)	5710.8 (495.6)
	25	2036.5 (700.4)			10.8 (10.8)		2047.3 (689.6)
	30	43.1 (0.0)	21.6 (21.6)				64.7 (21.6)
7 September	15	4460.9 (409.5)	21.6 (21.6)	21.6 (21.6)	1831.8 (107.8)	43.1 (0.0)	6378.8 (517.2)
	20	4439.3 (21.6)	43.1 (0.0)	64.7 (0.0)	1217.6 (247.8)	10.8 (10.8)	5775.4 (237.1)
	25	2338.2 (1777.9)		10.8 (10.8)	32.3 (10.8)		2381.3 (1777.9)
17 September	15	4288.5 (495.7)		21.6 (21.6)	2198.1 (86.2)	64.7 (64.7)	6572.8 (624.9)
	20	4353.1 (1163.7)	64.7 (21.6)	64.7 (21.6)	1131.4 (1002.1)	10.8 (10.8)	5624.6 (2176.6)
	25	2359.7 (1993.4)					2359.7 (1993.4)
	30	53.9 (10.8)					53.9 (10.8)
2 October	15	4374.7 (754.3)		43.1 (0.0)	711.2 (237.1)	21.6 (21.6)	5150.5 (1012.9)
	20	2133.5 (668.1)	43.1 (0.0)	107.8 (21.6)	689.6 (517.2)		2973.9 (1163.7)
	25	2413.6 (194.0)	21.6 (21.6)	21.6 (0.0)			2456.7 (215.5)
	30	150.9 (21.6)		21.6 (21.6)			172.4 (0.0)
29 October	15	—	—	—	—	—	—
	20	2866.2 (840.5)		172.4 (43.1)	1616.3 (237.0)		4654.8 (1120.6)
	25	2607.6 (1443.9)	21.6 (21.6)	21.6 (21.6)	21.6 (21.6)		2672.2 (1422.3)

Table 2b. Mean near-end densities (no.·m^{-2}) per sampling date of the major taxonomic groups collected during the open water season (May to November) at 20-m (1989-1991) and 25-m (1990-1991) intervals (± 2.5 m) from the south basin of Amisk Lake (South Amisk), 1988-1991. Standard errors are in parentheses. Blanks indicate densities of 0 animals·m^{-2}. '—' indicates that samples were not collected.

1989 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
12 May	20	323.3 (280.2)	10.8 (10.8)	43.1 (0.0)	118.5 (97.0)		495.7 (387.9)
26 May	20	571.1 (53.9)	32.3 (10.8)		301.7 (301.7)	10.8 (10.8)	915.9 (355.6)
14 June	20	2004.2 (818.9)	10.8 (10.8)	10.8 (10.8)	1185.3 (107.8)	21.6 (0.0)	3232.5 (689.6)
24 June	20	571.1 (183.2)	64.7 (64.7)		161.6 (10.8)	10.8 (10.8)	808.1 (140.1)
12 July	20	506.4 (53.9)	43.1 (43.1)	21.6 (0.0)	355.6 (204.7)	43.1 (43.1)	969.8 (344.8)
21 July	20	1648.6 (635.7)	32.3 (32.3)		1465.4 (754.3)	43.1 (43.1)	3189.4 (1465.4)
4 August	20	1433.1 (204.7)	75.4 (75.4)	10.8 (10.8)	1260.7 (808.1)		2780.0 (1077.5)
23 August	20	678.8 (334.0)	53.9 (53.9)	10.8 (10.8)	366.4 (280.2)	10.8 (10.8)	1120.6 (668.1)
8 September	20	452.6 (344.8)		43.1 (21.6)	237.1 (150.9)	10.8 (10.8)	743.5 (506.4)
2 October	20	517.2 (301.7)	10.8 (10.8)	21.6 (21.6)	528.0 (377.1)		1077.5 (668.1)
31 October	20	560.3 (194.0)	10.8 (10.8)	43.1 (43.1)	366.4 (86.2)		980.5 (53.9)

Table 2b. (cont.)

1990 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
10 May	20	118.5 (32.3)	10.8 (10.8)		43.1 (43.1)	10.8 (10.8)	183.2 (53.9)
	25	38.8 (20.9)		17.2 (8.1)	4.3 (4.3)	4.3 (4.3)	64.7 (22.6)
27 May	20	517.2 (344.8)	64.7 (43.1)	10.8 (10.8)	409.5 (387.9)	10.8 (10.8)	1012.9 (775.8)
	25	34.5 (18.8)	34.5 (11.0)	12.9 (12.9)	8.6 (5.3)	12.9 (8.6)	103.4 (36.3)
14 June	20	133.7 (9.5)	19.1 (9.6)	19.1 (9.6)	319.9 (4.8)	28.7 (9.6)	520.5 (23.9)
	25	42.6 (12.1)	76.1 (6.3)	12.4 (4.1)	9.6 (9.6)	48.8 (12.7)	189.4 (19.0)
26 June	20	269.4 (247.8)	21.6 (0.0)	10.8 (10.8)	280.2 (194.0)	10.8 (10.8)	592.6 (441.8)
	25	125.0 (71.9)	21.6 (16.7)	12.9 (5.3)	142.2 (90.3)	8.6 (5.3)	310.3 (151.4)
11 July	20	700.4 (247.8)	64.7 (43.1)	10.8 (10.8)	280.2 (21.6)	64.7 (21.6)	1120.6 (237.1)
	25	418.1 (115.0)	129.3 (36.1)	17.2 (4.3)	4.3 (4.3)	34.5 (16.1)	603.4 (155.5)
20 July	20	1336.1 (150.9)	43.1 (21.6)	32.3 (10.8)	237.1 (107.8)	10.8 (10.8)	1659.4 (237.0)
	25	448.2 (90.8)	69.0 (20.9)	8.6 (5.3)		56.0 (24.2)	581.9 (106.0)
1 August	20	2370.5 (1120.6)	32.3 (32.3)	10.8 (10.8)	431.0 (366.4)	10.8 (10.8)	2855.4 (1454.6)
	25	887.9 (200.1)	90.5 (33.0)	4.3 (4.3)	56.0 (35.8)	43.1 (18.0)	1081.8 (227.3)
17 August	20	1056.0 (150.8)	43.1 (43.1)	53.9 (10.8)	118.5 (118.5)	21.6 (21.6)	1293.0 (43.1)
	25	1124.9 (343.0)	64.7 (39.7)	4.3 (4.3)	99.1 (93.8)	12.9 (8.6)	1305.9 (473.9)
12 September	20	3846.7 (484.9)	43.1 (43.1)	32.3 (10.8)	743.5 (657.3)	21.6 (21.6)	4687.1 (1131.4)
	25	1245.6 (372.2)	51.7 (14.6)	47.4 (18.5)	133.6 (113.3)	4.3 (4.3)	1482.6 (435.5)
12 October	20	4708.7 (1411.5)	64.7 (0.0)	32.3 (32.3)	711.2 (474.1)	32.3 (32.3)	5549.1 (1950.3)
	25	943.9 (263.5)	17.2 (4.3)	8.6 (8.6)	12.9 (8.6)		982.7 (273.1)
7 November	20	4741.0 (754.2)	21.6 (21.6)	53.9 (53.9)	387.9 (172.4)		5204.3 (894.3)
	25	1495.6 (797.0)	12.9 (12.9)	25.9 (12.6)	103.4 (78.1)	8.6 (8.6)	1646.4 (904.3)

Table 2b. (concl.)

1991 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
6 May	20	2284.3 (818.9)	21.6 (21.6)		129.3 (129.3)		2435.2 (969.8)
	25	4353.1 (3749.7)	75.4 (75.4)		808.1 (808.1)		5236.7 (4633.3)
22 May	20	4654.8 (172.4)	43.1 (43.1)		452.6 (150.9)	21.6 (21.6)	5172.0 (387.9)
	25	1066.7 (140.1)	21.6 (0.0)	10.8 (10.8)		21.6 (21.6)	1120.6 (107.7)
29 May	20	5301.3 (301.7)	107.8 (21.6)		991.3 (172.4)		6400.4 (150.8)
	25	2252.0 (312.5)	53.9 (10.8)		32.3 (32.3)	10.8 (10.8)	2349.0 (258.6)
13 June	20	3642.0 (107.8)	43.1 (43.1)		431.0 (86.2)	43.1 (0.0)	4159.2 (64.7)
	25	883.6 (237.1)	64.7 (64.7)		21.6 (21.6)		969.8 (323.3)
26 June	20	3922.1 (991.3)	107.8 (64.7)		452.6 (64.7)	43.1 (43.1)	4525.5 (948.2)
	25	323.3 (150.9)	21.6 (21.6)				344.8 (129.3)
10 July	20	3685.1 (107.8)	86.2 (43.1)		1939.5 (948.2)	43.1 (0.0)	5753.9 (797.4)
	25	258.6 (43.1)	107.8 (21.6)				366.4 (64.7)
24 July	20	3685.1 (926.6)	86.2 (43.1)		1099.1 (237.1)	21.6 (21.6)	4891.9 (754.3)
	25	2047.3 (21.6)	107.8 (21.6)			43.1 (43.1)	2198.1 (43.1)
7 August	20	3642.0 (64.6)	107.8 (21.6)		1336.1 (0.0)		5085.8 (86.2)
	25	538.8 (323.3)	21.6 (21.6)	21.6 (21.6)			581.9 (323.3)
21 August	20	4245.4 (237.1)	107.8 (21.6)	21.6 (21.6)	840.5 (107.8)		5215.1 (344.8)
	25	1336.1 (862.0)			21.6 (21.6)		1357.7 (883.6)
7 September	20	4460.9 (64.7)	43.1 (0.0)	64.7 (21.6)	969.8 (237.0)		5538.4 (193.9)
	25	560.3 (0.0)			43.1 (0.0)		603.4 (0.0)
17 September	20	3189.4 (172.4)	86.2 (86.2)	43.1 (0.0)	129.3 (43.1)		3448.0 (215.5)
	25	366.4 (107.8)					366.4 (107.8)
2 October	20	1465.4 (905.1)	43.1 (43.1)	129.3 (129.3)	172.4 (43.1)		1810.2 (775.8)
	25	2607.6 (2262.8)	43.1 (0.0)	21.6 (21.6)			2672.2 (2241.2)
29 October	20	—	—	—	—	—	—
	25	—	—	—	—	—	—

Table 2c. Mean far-end densities (no.·m^{-2}) per sampling date of the major taxonomic groups collected during the open water season (May to November) at 20-m (1989-1991) and 25-m (1990-1991) intervals (± 2.5 m) from the south basin of Amisk Lake (South Amisk), 1988-1991. Standard errors are in parentheses. Blanks indicate densities of 0 animals·m^{-2}.

1989 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
12 May	20	344.8 (21.6)		10.8 (10.8)	32.3 (32.3)		387.9 (21.5)
26 May	20	872.8 (398.7)	21.6 (0.0)	21.6 (21.6)	883.6 (668.1)	10.8 (10.8)	1810.2 (301.7)
14 June	20	226.3 (161.6)	10.8 (10.8)	21.6 (21.6)	53.9 (53.9)	10.8 (10.8)	323.3 (129.3)
24 June	20	635.7 (269.4)	21.6 (21.6)	10.8 (10.8)	183.2 (161.6)	107.8 (21.6)	959.0 (463.3)
12 July	20	754.3 (129.3)	32.3 (32.3)	10.8 (10.8)	377.1 (377.1)	10.8 (10.8)	1185.3 (538.8)
21 July	20	1142.2 (409.5)	64.7 (21.6)		743.5 (635.7)	64.7 (43.1)	2014.9 (980.5)
4 August	20	592.6 (247.8)	53.9 (10.8)		97.0 (53.9)	21.6 (21.6)	765.0 (269.4)
23 August	20	317.9 (91.6)	21.6 (21.6)	32.4 (0.0)	75.4 (32.3)		387.9 (86.2)
8 September	20	398.7 (334.0)		21.6 (0.0)	32.3 (10.8)		452.6 (323.3)
2 October	20	355.6 (118.5)		43.1 (0.0)	215.5 (194.0)	21.6 (0.0)	635.7 (312.5)
31 October	20	646.5 (538.8)	10.8 (10.8)	118.5 (53.9)	377.1 (312.5)	10.8 (10.8)	1163.7 (797.4)

Table 2c. (cont.)

1990

Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
10 May	20	1163.7 (172.4)		21.6 (21.6)	495.7 (150.9)		1680.9 (43.1)
	25	107.8 (26.4)	10.8 (6.2)	32.3 (13.9)	5.4 (5.4)		156.2 (25.5)
27 May	20	431.0 (86.2)		107.8 (21.6)	301.7 (172.4)		840.5 (64.6)
	25	64.7 (23.3)	32.3 (10.8)	37.7 (10.3)		10.8 (10.8)	145.5 (35.6)
14 June	20	64.7 (21.6)	21.6 (21.6)		43.1 (0.0)	21.6 (21.6)	150.9 (21.6)
	25	64.7 (34.1)	26.9 (5.4)	10.8 (6.2)	5.4 (5.4)	26.9 (13.6)	134.7 (35.6)
26 June	20	258.6 (43.1)	43.1 (0.0)		452.6 (323.3)		754.3 (366.4)
	25	32.3 (10.8)	10.8 (10.8)	10.8 (10.8)	5.4 (5.4)	26.9 (13.6)	86.2 (34.1)
11 July	20	495.7 (21.6)			452.6 (21.6)	43.1 (0.0)	991.3 (0.0)
	25	247.8 (100.5)	48.5 (16.2)	5.4 (5.4)		10.8 (6.2)	312.5 (109.4)
20 July	20	1680.9 (387.9)	43.1 (43.1)		258.6 (129.3)	21.6 (21.6)	2004.2 (495.7)
	25	544.1 (213.9)	32.3 (6.2)	10.8 (10.8)	26.9 (13.6)	26.9 (10.3)	641.1 (231.5)
1 August	20	2542.9 (215.5)	43.1 (0.0)	43.1 (0.0)	1767.1 (646.5)	21.6 (21.6)	4417.8 (840.4)
	25	727.3 (165.1)	64.7 (15.2)		5.4 (5.4)	10.8 (6.2)	808.1 (166.3)
17 August	20	1077.5 (387.9)	43.1 (43.1)		129.3 (86.2)	21.6 (21.6)	1271.5 (495.7)
	25	721.9 (304.1)	43.1 (8.8)	10.8 (6.2)	32.3 (18.7)	5.4 (5.4)	813.5 (316.2)
12 September	20	1249.9 (215.5)	86.2 (86.2)	64.7 (21.6)	366.4 (237.1)	21.6 (21.6)	1788.7 (581.9)
	25	1066.7 (321.4)	32.3 (6.2)	37.7 (13.6)	21.6 (21.6)	5.4 (5.4)	1163.7 (329.5)
12 October	20	4568.6 (129.3)	43.1 (0.0)	107.8 (107.8)	797.4 (107.8)	43.1 (43.1)	5559.9 (387.9)
	25	1934.1 (552.4)	26.9 (10.3)	64.7 (15.2)	21.6 (21.6)		2047.3 (544.8)
7 November	20	7305.5 (495.7)	689.6 (86.2)	64.7 (21.6)	1120.6 (43.1)	43.1 (43.1)	9223.4 (689.6)
	25	1610.9 (160.9)	43.1 (24.9)	43.1 (0.0)	5.4 (5.4)		1702.5 (178.4)

Table 2c. (concl.)

1991

Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
6 May	20	7995.1 (1831.8)	107.8 (21.6)		3943.7 (2262.8)		12046.5 (4073.0)
	25	5279.8 (21.6)		21.6 (21.6)	301.7 (0.0)		5603.0 (43.1)
22 May	20	3211.0 (280.1)	64.7 (21.6)	21.6 (21.6)	172.4 (129.3)	21.6 (21.6)	3491.1 (387.9)
	25	1616.3 (625.0)		21.6 (21.6)			1637.8 (603.4)
29 May	20	6184.9 (581.9)	43.1 (43.1)	21.6 (21.6)	431.0 (258.6)	21.6 (21.6)	6702.1 (366.4)
	25	1508.5 (1120.6)					1508.5 (1120.6)
13 June	20	4568.6 (818.9)	64.7 (21.6)	21.6 (21.6)	2866.2 (840.5)	43.1 (43.1)	7564.1 (1659.4)
	25	2262.8 (754.3)			64.7 (21.6)		2327.4 (775.8)
26 June	20	5861.6 (689.6)	107.8 (21.6)	21.6 (21.6)	862.0 (0.0)	21.6 (21.6)	6874.5 (711.2)
	25	2586.0 (517.2)		21.6 (21.6)		21.6 (21.6)	2629.1 (474.1)
10 July	20	5452.2 (581.9)	237.1 (107.8)		1659.4 (323.3)	150.9 (21.6)	7499.4 (1034.4)
	25	3749.7 (646.5)				43.1 (0.0)	3792.8 (646.5)
24 July	20	4590.2 (64.7)	43.1 (43.1)		883.6 (237.1)	43.1 (43.1)	5559.9 (387.9)
	25	2004.2 (495.7)	21.6 (21.6)		21.6 (21.6)		2047.3 (538.8)
7 August	20	4784.1 (172.4)	150.9 (21.6)	21.6 (21.6)	129.3 (43.1)		5085.8 (215.5)
	25	2392.1 (323.3)	21.6 (21.6)		64.7 (64.7)		2478.3 (409.5)
21 August	20	4223.8 (948.2)	86.2 (0.0)	64.7 (64.7)	1788.7 (237.0)	43.1 (43.1)	6206.4 (689.6)
	25	2736.9 (1918.0)					2736.9 (1918.0)
7 September	20	4417.8 (366.4)	43.1 (0.0)	64.7 (64.7)	1465.4 (86.2)	21.6 (21.6)	6012.5 (409.5)
	25	4116.1 (926.6)		21.6 (21.6)	21.6 (21.6)		4159.2 (969.8)
17 September	20	5516.8 (560.3)	43.1 (0.0)	86.2 (0.0)	2133.5 (581.9)	21.6 (21.6)	7801.1 (0.0)
	25	4353.1 (1077.5)					4353.1 (1077.5)
2 October	20	2801.5 (86.2)	43.1 (43.1)	86.2 (43.1)	1206.8 (129.3)		4137.6 (43.1)
	25	2219.7 (1918.0)		21.6 (21.6)			2241.2 (1896.4)
29 October	20	2866.2 (840.5)		172.4 (43.1)	1616.3 (237.0)		4654.8 (1120.6)
	25	2607.6 (1443.9)	21.6 (21.6)	21.6 (21.6)	21.6 (21.6)		2672.2 (1422.3)

Table 3. Mean whole-basin densities (no.·m^{-2}) per sampling date of the major taxonomic groups collected during the open water season (May to November) at 15-, 20-, and 25-m (± 2.5 m) intervals from the south basin of Baptiste Lake (South Baptiste), 1988-1991. Standard errors are in parentheses. Blanks indicate densities of 0 animals·m^{-2}. '—' indicates that samples were not collected.

1988 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
15 May	15	517.2 (387.9)	43.1 (0.0)	1357.7 (1012.9)	452.6 (452.6)		2370.5 (1853.3)
	20	86.2 (86.2)	21.6 (21.6)	8124.4 (2650.7)			8232.1 (2758.4)
	25		43.1 (0.0)	2047.3 (150.8)		21.6 (21.6)	2111.9 (129.3)
19 June	15	689.6 (474.1)	150.9 (64.7)	829.7 (204.7)	1325.3 (1045.2)	32.3 (32.3)	3027.8 (1627.0)
	20	150.9 (43.1)	107.8 (43.1)	657.3 (53.9)	21.6 (0.0)	32.3 (10.8)	969.8 (64.6)
	25	64.7 (21.6)	194.0 (64.7)	797.4 (86.2)			1056.0 (172.4)
9 July	15	420.2 (118.5)	75.4 (10.8)	97.0 (75.4)	5430.6 (2973.9)		6023.2 (2790.7)
	20	161.6 (75.4)	32.3 (10.8)	118.5 (10.8)	10.8 (10.8)		323.3 (64.6)
	25	86.2 (0.0)	150.9 (43.1)	226.3 (10.8)		10.8 (10.8)	474.1 (64.7)
28 July	15	657.3 (32.3)	75.4 (10.8)	194.0 (86.2)	678.8 (571.1)	10.8 (10.8)	1616.3 (603.4)
	20	64.7 (21.6)	86.2 (64.7)	431.0 (107.8)			581.9 (21.5)
	25	21.6 (0.0)	129.3 (21.6)	668.1 (194.0)			818.9 (215.5)
10 August	15	581.9 (129.3)	97.0 (32.3)	387.9 (301.7)	4568.6 (3318.7)	43.1 (21.6)	5678.4 (3803.6)
	20	75.4 (10.8)	97.0 (53.9)	517.2 (237.1)		10.8 (10.8)	700.4 (161.6)
	25	64.7 (0.0)	43.1 (0.0)	237.1 (21.6)	10.8 (10.8)		355.6 (32.3)
25 August	15	334.0 (53.9)	21.6 (0.0)	2014.9 (1562.4)	603.4 (344.8)	10.8 (10.8)	2984.7 (1950.3)
	20	161.6 (32.3)	43.1 (0.0)	1185.3 (905.1)		21.6 (21.6)	1411.5 (851.2)
	25	21.6 (0.0)	21.6 (21.6)	1821.0 (765.0)	10.8 (10.8)	32.3 (32.3)	1907.2 (786.6)
11 September	15	700.4 (53.9)	10.8 (10.8)	1530.1 (560.3)	1422.3 (1314.6)	32.3 (10.8)	3695.8 (786.6)
	20	118.5 (32.3)		1293.0 (129.3)	10.8 (10.8)		1422.3 (172.4)
	25	32.3 (32.3)	21.6 (0.0)	538.8 (194.0)		32.3 (32.3)	625.0 (129.3)
9 October	15	194.0 (64.7)		3027.8 (377.1)	452.6 (258.6)		3674.3 (183.2)
	20	97.0 (75.4)	10.8 (10.8)	2909.3 (150.9)	10.8 (10.8)		3027.8 (226.3)
	25	21.6 (0.0)		1637.8 (64.6)			1659.4 (64.6)
5 November	15	937.4 (420.2)	1217.6 (1152.9)	1314.6 (150.9)	1745.6 (603.4)	32.3 (32.3)	5247.4 (851.2)
	20	75.4 (10.8)		5409.1 (107.8)	10.8 (10.8)		5495.3 (107.8)
	25	43.1 (43.1)		2155.0 (129.3)		10.8 (10.8)	2208.9 (161.6)

Table 3 (cont.)

1989 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
14 May	15	792.0 (446.3)	215.5 (101.1)	2349.0 (813.3)	3954.4 (2823.7)	43.1 (23.3)	7353.9 (2807.6)
	20	32.3 (10.8)	26.9 (20.4)	2451.3 (816.0)	21.6 (21.6)	5.4 (5.4)	2537.5 (857.6)
	25		32.3 (32.3)	2898.5 (32.3)	10.8 (10.8)		2941.6 (10.8)
27 May	15	350.2 (106.8)	59.3 (36.7)	1039.8 (663.3)	3922.1 (2984.9)	37.7 (25.5)	5409.1 (3016.2)
	20	37.7 (37.7)		2122.7 (553.0)	59.3 (59.3)	5.4 (5.4)	2225.0 (536.0)
	25			2155.0 (301.7)		21.6 (21.6)	2176.6 (280.2)
16 June	15	587.2 (286.8)	97.0 (43.5)	2505.2 (2139.0)	3636.6 (2986.7)	26.9 (10.3)	6852.9 (2923.3)
	20	37.7 (18.4)	26.9 (13.6)	2774.6 (1434.6)	10.8 (10.8)		2850.0 (1417.1)
	25		43.1 (43.1)	818.9 (86.2)			862.0 (43.1)
30 June	15	711.2 (402.1)	118.5 (56.0)	711.2 (392.8)	1573.2 (800.4)	37.7 (16.2)	3151.7 (931.8)
	20	16.2 (10.8)	48.5 (28.3)	544.1 (92.8)			608.8 (113.1)
	25	10.8 (10.8)	21.6 (21.6)	571.1 (97.0)			603.4 (107.8)
14 July	15	463.3 (199.2)	64.7 (51.3)	258.6 (137.40	802.7 (332.6)	75.4 (43.5)	1664.7 (379.1)
	20	86.2 (17.6)	10.8 (6.2)	344.8 (186.8)	5.4 (5.4)	10.8 (6.2)	457.9 (164.0)
	25	10.8 (10.8)		64.7 (0.0)			75.4 (10.8)
27 July	15	328.6 (162.8)	48.5 (35.6)	673.4 (185.0)	765.0 (311.5)	21.6 90.0)	1837.1 (327.9)
	20	53.9 (18.7)	32.3 (18.7)	662.7 (63.7)	10.8 (6.2)		759.6 (68.4)
	25		10.8 (10.8)	743.5 (312.5)			754.3 (301.7)
8 August	15	409.5 9254.5)	32.3 (20.6)	4116.1 (1506.7)	937.4 (474.9)	5.4 (5.4)	5500.6 (1750.0)
	20	21.6 (8.8)	10.8 (10.8)	2365.1 (553.8)	5.4 (5.4)	5.4 (5.4)	2408.2 (545.0)
	25		10.8 (10.8)	862.0 (172.4)			872.8 (183.2)
28 August	15	129.3 (52.8)		3211.0 (992.7)	1923.3 (1157.2)	5.4 (5.4)	5269.0 (2084.0)
	20	21.6 (21.6)	5.4 (5.4)	1357.7 (319.8)		5.4 (5.4)	1390.0 (337.4)
	25	10.8 (10.8)		1530.1 (21.6)		10.8 (10.8)	1551.6 (0.0)
9 September	15	328.6 (94.5)	5.4 (5.4)	5619.2 (1394.4)	996.7 (243.4)	21.6 (21.6)	6971.4 (1277.8)
	20			1616.3 (420.2)		5.4 (5.4)	1621.6 (425.1)
	25			1357.7 (21.5)			1357.7 (21.5)
4 October	15	317.9 (109.3)	5.4 (5.4)	13431.0 (1326.5)	2138.8 (866.2)	10.8 (6.2)	15903.9 (576.8)
	20	37.7 (34.5)		7321.6 (1085.7)	5.4 (5.4)		7364.7 (1098.3)
	25			3394.1 (1066.7)			3394.1 (1066.7)
3 November	15	—	—	—	—	—	—
	20	43.1 (30.5)		9535.9 (2382.5)		10.8 (6.2)	9589.8 (2404.4)
	25	32.3 (10.8)		13695.0 (484.9)		10.8 (10.8)	13738.1 (506.4)

Table 3 (cont.)

1990 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
11 May	15	463.3 (420.2)	21.6 (21.6)	4277.7 (3307.9)	2758.4 (2758.4)	21.6 (21.6)	7542.5 (6529.7)
	20	35.9 (35.90		11162.9 (6714.1)	14.4 (14.4)		11213.2 (6764.4)
	25	16.8 (7.0)	7.2 (5.10	17046.1 (2246.5)		2.4 (2.4)	17072.4 (2247.8)
29 May	15	581.9 (560.3)	43.1 (0.0)	9945.3 (9643.6)	1734.8 (1088.3)	21.6 (0.0)	12326.6 (11292.2)
	20	28.7 (28.7)	7.2 (7.2)	7291.1 (5548.9)	7.2 (7.2)		7334.2 (5568.9)
	25	9.6 (5.2)	9.6 (5.2)	5871.2 (396.5)		2.4 (2.4)	5892.7 (402.8)
15 June	15	859.5 (821.3)	4.8 (4.8)	7926.5 (76.4)	1403.9 (1394.3)	33.4 (33.4)	10228.1 (2177.4)
	20	12.7 (12.7)	6.4 (3.2)	6592.7 (5486.3)		9.6 (5.5)	6621.3 (5505.4)
	25	26.7 (13.0)	21.0 (3.6)	4658.5 (727.0)		3.8 (2.3)	4710.1 (724.4)
27 June	15	64.7 964.7)	10.8 (10.8)	1045.2 (441.8)	53.9 (32.3)	21.6 (0.0)	1196.0 (528.0)
	20	28.7 (19.0)	50.3 (40.0)	1580.3 (1052.8)	7.2 (7.2)	28.7 (19.0)	1695.3 (1017.4)
	25	9.6 (3.8)	14.4 (7.2)	5389.9 (909.9)		2.4 (2.4)	5416.2 (915.0)
12 July	15	129.3 (129.3)	21.6 (21.6)	344.8 (150.9)	818.9 (797.4)	10.8 (10.8)	1325.3 (1109.8)
	20	79.0 (50.3)	7.2 (7.2)	517.2 (126.3)	7.2 (7.2)	14.4 (14.4)	625.0 (143.5)
	25	14.4 (8.0)	9.6 (7.3)	672.8 (149.9)		4.8 (3.2)	701.6 (146.8)
23 July	15	161.6 (161.6)		258.6 (0.0)	678.8 (635.7)	32.3 (10.8)	1131.4 (808.1)
	20	35.9 (25.9)	14.4 (14.4)	258.6 (32.9)	129.3 (129.3)		438.2 (162.4)
	25		9.6 (5.2)	332.8 (46.0)		4.8 (3.2)	347.2 (44.8)
7 August	15	161.6 (118.5)	10.8 (10.8)	851.2 (10.8)	387.9 (387.9)	10.8 (10.8)	1422.3 (495.7)
	20	35.9 (25.9)	14.4 (7.2)	862.0 (552.4)	14.4 (14.4)		926.7 (519.6)
	25	7.2 (3.6)	7.2 (5.1)	720.7 (133.5)		2.4 (2.4)	737.5 (130.9)
20 August	15	107.8 (64.70		3329.5 (571.1)	409.5 (366.4)	21.6 (0.0)	3868.2 (140.1)
	20	43.1 (21.6)	14.4 (14.4)	1257.1 (307.4)		7.2 (7.2)	1321.7 (298.7)
	25	9.6 (6.3)	2.4 (2.4)	1319.3 (158.1)		9.6 (5.2)	1340.9 (157.1)
14 September	15	172.4 (150.9)	10.8 (10.8)	3275.6 (862.0)	334.0 (312.5)		3792.8 (387.9)
	20	57.5 (38.0)		3728.2 (1368.4)	100.6 (100.6)		3886.2 (1505.0)
	25	7.2 (5.1)	4.8 (3.2)	2095.1 (168.3)		4.8 (3.2)	2111.9 (167.7)
13 October	15	344.8 (301.7)	32.3 (32.3)	5656.9 (506.4)	969.8 (969.8)		7003.8 (797.4)
	20	14.4 (14.4)	21.6 (21.6)	4195.1 (307.1)			4231.0 (341.7)
	25	14.4 (9.5)		3553.4 (137.4)		2.4 (2.4)	3570.1 (139.7)
8 November	15	247.8 (183.2)	53.9 (53.9)	6055.6 (4094.5)	948.2 (625.0)		7305.5 (3232.5)
	20	7.2 (7.2)	14.4 (14.4)	8857.1 (1772.2)		7.2 (7.2)	8885.8 (1777.2)
	25	14.4 (14.4)		6091.5 (1012.1)			6105.8 (1026.1)

Table 3 (concl.)

1991 Date	Depth (m)	Chironomus spp.	other chironomid genera	Chaoborus spp.	Oligochaeta	other taxa	TOTAL DENSITY
9 May	15	560.3 (43.1)	107.8 (64.7)	2564.5 (21.5)	3771.3 (280.2)		7003.8 (323.3)
	20	43.1 (43.1)	64.7 (64.7)	6238.7 (1928.7)	10.8 (10.8)		6357.3 (2025.7)
	25	10.8 (10.8)	32.3 (10.8)	7186.9 (721.9)			7230.0 (721.9)
23 May	15	237.1 (21.6)	43.1 (43.1)	1249.9 (86.2)	344.8 (86.2)	21.6 (21.6)	1896.4 (215.5)
	20	64.7 (43.1)	53.9 (32.3)	1368.4 (571.1)		10.8 (10.8)	1497.7 (635.7)
	25	21.6 (0.0)	161.6 (32.3)	3943.7 (64.6)		21.6 (0.0)	4148.4 (97.0)
31 May	15	172.4 (86.2)	43.1 (0.0)	2305.9 (452.6)	2133.5 (711.2)	21.6 (21.6)	4676.4 (366.3)
	20	43.1 (43.1)	53.9 (53.9)	3415.7 (247.8)	10.8 (10.8)	10.8 (10.8)	3534.2 (150.8)
	25	10.8 (10.8)	86.2 (43.1)	3286.4 (312.5)		21.6 (21.6)	3404.9 (237.0)
14 June	15	150.9 (64.7)	64.7 (64.7)	237.1 (21.6)	1616.3 (797.4)		2068.8 (818.9)
	20	21.6 (0.0)	86.2 (43.1)	1680.9 (1034.4)			1788.7 (991.3)
	25		64.7 (21.6)	1109.8 (140.1)		10.8 (10.8)	1185.3 (150.9)
28 June	15	280.2 (64.7)	43.1 (43.1)	474.1 (43.1)	4633.3 (323.3)	21.6 (21.6)	5452.2 (366.3)
	20		161.6 (118.5)	808.1 (355.6)			969.8 (237.1)
	25	21.6 (21.6)	140.1 (32.3)	926.7 (43.1)		10.8 (10.8)	1099.1 (107.8)
8 July	15	258.6 (0.0)	150.9 (21.6)	172.4 (86.2)	1594.7 (431.0)		2176.6 (495.7)
	20	32.3 (32.3)	53.9 (53.9)	301.7 (215.5)		10.8 (10.8)	398.7 (118.5)
	25		107.8 (21.6)	678.8 (10.8)			786.6 (10.8)
26 July	15	129.3 (0.0)	129.3 (0.0)	215.5 (43.1)	862.0 (215.5)		1336.1 (258.6)
	20	32.3 (32.3)	53.9 (32.3)	140.1 (75.4)	21.6 (0.0)	10.8 (10.8)	258.6 (0.0)
	25	10.8 (10.8)	21.6 (0.0)	150.9 (21.6)			183.2 (32.3)
8 August	15	316.1 (51.8)	100.6 (14.4)	71.8 (28.7)	4597.3 (2414.8)	14.4 (14.4)	5100.2 (2478.9)
	20	10.8 (10.8)	10.8 (10.8)	97.0 (32.3)	107.8 (107.8)		226.3 (161.6)
	25		32.3 (10.8)	140.1 (10.8)			172.4 (21.6)
23 August	15	323.3 (150.9)	21.6 (21.6)	86.2 (0.0)	4482.4 (603.4)		4913.4 (732.7)
	20	53.9 (53.9)		43.1 (43.1)			97.0 (97.0)
	25		53.9 (32.3)	75.4 (53.9)			129.3 (86.2)
8 September	15	258.6 (172.4)	21.6 (21.6)	107.8 (21.6)	3814.4 (883.6)		4202.3 91056.0)
	20	53.9 (53.9)		86.2 (64.7)	32.3 (10.8)		172.4 (0.0)
	25		32.3 (10.8)	97.0 (32.3)			129.3 (43.1)
18 September	15	150.9 (64.7)		431.0 (0.0)	818.9 (129.3)		1400.8 (194.0)
	20	43.1 (43.1)		129.3 (43.1)			172.4 (0.0)
	25			86.2 (64.7)			86.2 (64.7)
30 October	15	—	—	—	—	—	—
	20	10.8 (10.8)	10.8 (10.8)	344.8 (194.0)	172.4 (172.4)	10.8 (10.8)	549.5 (398.7)
	25			86.2 (64.7)			86.2 (64.7)

Table 4. Mean whole-basin densities (no.·m^{-2}) ± SE per sampling date of Chironomus species collected during the open water season (May to November) at 15-, 20-, 25-, and 30-m (± 2.5 m) intervals from the north basin of Amisk Lake (North Amisk), 1988-1991. Blanks indicate densities of 0 animals·m^{-2}. '—' indicates that samples were not collected.

1988

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
16 May	15	43.1 ± 31.0	10.8 ± 7.4	463.3 ± 295.0	3.6 ± 3.6	28.7 ± 28.7	107.8 ± 45.9
	20			154.4 ± 42.9	3.6 ± 3.6		28.7 ± 28.7
	25		21.6 ± 0.0	10.8 ± 10.8			10.8 ± 10.8
	30			21.6 ± 21.6			
10 June	15	28.7 ± 10.7		323.3 ± 140.5		7.2 ± 4.5	
	20			150.9 ± 35.1	5.4 ± 4.8		
	25			21.6 ± 0.0			
	30			10.8 ± 10.8			
23 June	15	25.1 ± 14.1	14.4 ± 7.2	179.6 ± 31.3		18.0 ± 18.0	
	20		25.9 ± 17.2	142.2 ± 32.4	4.3 ± 4.3		
	25		10.8 ± 10.8	64.7 ± 21.6			
	30			10.8 ± 10.8			
5 July	15	7.2 ± 4.5	32.3 ± 12.1	186.8 ± 36.8	10.8 ± 7.4	316.1 ± 119.0	
	20		4.3 ± 4.3	94.8 ± 37.7		30.2 ± 12.9	
	25	10.8 ± 10.8	10.8 ± 10.8	53.9 ± 10.8		10.8 ± 10.8	
	30			86.2 ± 21.6			
20 July	15	46.7 ± 26.3	10.8 ± 10.8	114.9 ± 40.4	18.0 ± 6.6	524.4 ± 240.9	
	20		4.3 ± 4.3	202.6 ± 78.5	4.3 ± 4.3	21.6 ± 13.6	
	25		10.8 ± 10.8	43.1 ± 0.0		32.3 ± 32.3	
	30			21.6 ± 0.0			
2 August	15	43.1 ± 20.1	18.0 ± 6.6	7.2 ± 4.5	3.6 ± 3.6	775.8 ± 277.4	
	20	17.2 ± 12.6	21.6 ± 16.7	185.3 ± 71.3			
	25			118.5 ± 75.4			
	30			32.3 ± 10.8			
18 August	15	93.4 ± 89.1	3.6 ± 3.6		21.6 ± 7.9	984.1 ± 639.7	
	20	86.2 ± 86.2	8.6 ± 5.3	43.1 ± 19.3	4.3 ± 4.3	21.6 ± 13.6	
	25		21.6 ± 21.6	64.7 ± 64.7			
	30			10.8 ± 10.8		43.1 ± 43.1	
8 September	15	61.1 ± 36.7	39.5 ± 19.6		3.6 ± 3.6	445.4 ± 192.1	
	20	4.3 ± 4.3	12.9 ± 8.6	17.2 ± 12.6	4.3 ± 4.3	43.1 ± 37.9	
	25		10.8 ± 10.8	21.6 ± 21.6		53.9 ± 10.8	
	30			75.4 ± 53.9			
7 October	15	1569.6 ± 1140.9	18.0 ± 8.6		10.8 ± 4.8	308.9 ± 98.1	
	20	4.3 ± 4.3	12.9 ± 8.6	56.0 ± 46.0		129.3 ± 80.8	
	25	10.8 ± 10.8	32.3 ± 10.8	10.8 ± 10.8	10.8 ± 10.8	86.2 ± 86.2	
	30					21.6 ± 21.6	
3 November	15	1691.7 ± 388.5	68.2 ± 19.6	933.8 ± 214.4	46.7 ± 14.1	57.5 ± 57.5	
	20	887.9 ± 519.6	43.1 ± 32.7	659.4 ± 499.7	17.2 ± 8.1	137.9 ± 137.9	
	25	312.5 ± 161.6	21.6 ± 21.6	21.6 ± 21.6			
	30	53.9 ± 10.8		10.8 ± 10.8	21.6 ± 21.6		

Table 4 (cont.)

1989

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
7 May	15	1217.6 ± 440.3	48.5 ± 26.9	1158.3 ± 653.1	80.8 ± 28.3		16.2 ± 16.2
	20	845.8 ± 500.9	32.3 ± 13.9	1158.3 ± 556.3	10.8 ± 6.2		10.8 ± 10.8
	25	150.9 ± 64.7	21.6 ± 21.6	10.8 ± 10.8	21.6 ± 21.6	10.8 ± 10.8	
25 May	15	1298.4 ± 540.4	37.7 ± 18.4	506.4 ± 196.2	70.0 ± 34.5	10.8 ± 10.8	10.8 ± 10.8
	20	571.1 ± 350.6	16.2 ± 10.3	910.5 ± 156.7	21.6 ± 8.8		53.9 ± 20.6
	25	161.6 ± 32.3		247.8 ± 32.3			
12 June	15	1212.2 ± 371.3	26.9 ± 20.4	484.9 ± 127.0	118.5 ± 47.8	10.8 ± 6.2	
	20	533.4 ± 271.2	48.5 ± 18.4	754.3 ± 159.3	16.2 ± 10.3		5.4 ± 5.4
	25	75.4 ± 75.4		183.2 ± 161.6		10.8 ± 10.8	
23 June	15	932.0 ± 300.2	32.3 ± 18.7	484.9 ± 98.6	91.6 ± 63.1		
	20	603.4 ± 532.2	16.2 ± 5.4	522.6 ± 236.0	32.3 ± 13.9		5.4 ± 5.4
	25	538.8 ± 366.4	32.3 ± 10.8	441.8 ± 204.7	10.8 ± 10.8		
10 July	15	926.7 ± 250.4	26.9 ± 13.6	387.9 ± 44.0	118.5 ± 78.9	5.4 ± 5.4	
	20	317.9 ± 226.3	5.4 ± 5.4	576.5 ± 35.6	21.6 ± 21.6		
	25	86.2 ± 21.6		377.1 ± 53.9	10.8 ± 10.8		
20 July	15	932.0 ± 283.5	48.5 ± 30.9	398.7 ± 102.0	75.4 ± 20.6		5.4 ± 5.4
	20	738.1 ± 436.9	37.7 ± 10.3	560.3 ± 137.1	16.2 ± 5.4		
	25	194.0 ± 172.4	32.3 ± 32.3	118.5 ± 10.8	21.6 ± 21.6		
3 August	15	1088.3 ± 260.2	5.4 ± 5.4	140.1 ± 31.1	113.1 ± 47.7	21.6 ± 21.6	
	20	571.1 ± 428.5	43.1 ± 17.6	296.3 ± 117.8	16.2 ± 5.4		
	25	646.5 ± 625.0	75.4 ± 75.4	118.5 ± 97.0	10.8 ± 10.8		
21 August	15	748.9 ± 266.2	59.3 ± 33.4	10.8 ± 10.8	59.3 ± 45.2	21.6 ± 21.6	
	20	689.6 ± 425.3	37.7 ± 22.2	26.9 ± 10.3			10.8 ± 6.2
	25	194.0 ± 43.1	21.6 ± 21.6				
7 September	15	511.8 ± 197.8	21.6 ± 8.8		43.1 ± 30.5		
	20	199.3 ± 171.1	10.8 ± 6.2	5.4 ± 5.4	10.8 ± 6.2		
	25	129.3 ± 107.8	21.6 ± 21.6				
1 October	15	630.3 ± 233.0	59.3 ± 20.4		64.7 ± 26.4	5.4 ± 5.4	
	20	264.0 ± 242.6			5.4 ± 5.4		
	25	140.1 ± 97.0	21.6 ± 21.6		10.8 ± 10.8		
31 October	15	—	—	—	—	—	—
	20	533.4 ± 263.0	53.9 ± 13.9	1077.5 ± 766.7	32.3 ± 18.7		
	25	431.0 ± 301.7	64.7 ± 21.6	172.4 ± 107.7	21.6 ± 0.0		

Table 4 (cont.)

1990

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
9 May	15	161.6 ± 75.4		237.1 ± 194.0	183.2 ± 161.6	183.2 ± 118.5	355.6 ± 183.2
	20	93.4 ± 56.1	7.2 ± 7.2	431.0 ± 176.4	64.7 ± 32.9	14.4 ± 14.4	359.2 ± 241.7
	25	8.6 ± 8.6	17.2 ± 12.6	86.2 ± 37.3	34.5 ± 29.4	4.3 ± 4.3	56.0 ± 26.0
26 May	15	53.9 ± 53.9	10.8 ± 10.8	312.5 ± 10.8	161.6 ± 53.9	129.3 ± 64.7	43.1 ± 43.1
	20	21.6 ± 12.4	28.7 ± 7.2	452.6 ± 131.7	71.8 ± 31.3	50.3 ± 40.0	43.1 ± 12.4
	25	8.6 ± 8.6		129.3 ± 55.8	17.2 ± 8.1	12.9 ± 8.6	69.0 ± 40.0
11 June	15		21.6 ± 0.0	614.2 ± 204.7	172.4 ± 107.7	506.4 ± 269.4	
	20	7.2 ± 7.2		330.4 ± 43.7	50.3 ± 50.3	43.1 ± 32.9	
	25		17.2 ± 12.6	163.8 ± 48.5	60.3 ± 26.7	4.3 ± 4.3	
22 June	15	10.8 ± 10.8		194.0 ± 107.8	43.1 ± 43.1	64.7 ± 0.0	
	20		14.4 ± 14.4	222.7 ± 31.3	57.5 ± 47.1		
	25	8.6 ± 5.3	4.3 ± 4.3	116.4 ± 41.8	4.3 ± 4.3	8.6 ± 5.3	
10 July	15		21.6 ± 21.6	226.3 ± 118.5	129.3 ± 129.3	1249.9 ± 926.7	
	20	7.2 ± 7.2	35.9 ± 35.9	409.5 ± 81.6		459.7 ± 181.3	
	25	4.3 ± 4.3	43.1 ± 22.6	250.0 ± 53.9	38.8 ± 8.1	284.5 ± 73.8	
19 July	15	32.3 ± 32.3	75.4 ± 10.8	420.2 ± 183.2	204.7 ± 161.6	1831.8 ± 1293.0	
	20		64.7 ± 32.9	359.2 ± 127.1	114.9 ± 38.0	976.9 ± 429.6	
	25	17.2 ± 8.1	77.6 ± 36.4	262.9 ± 52.1	25.9 ± 4.3	530.1 ± 198.8	
3 August	15	97.0 ± 97.0	64.7 ± 21.6	43.1 ± 43.1	64.7 ± 64.7	991.3 ± 366.4	
	20	244.2 ± 101.3	165.2 ± 25.9	143.7 ± 40.0	50.3 ± 7.2	2018.5 ± 1621.3	
	25	112.1 ± 41.7	112.1 ± 47.9	120.7 ± 30.9	21.6 ± 6.8	564.6 ± 258.9	
16 August	15	323.3 ± 301.7			64.7 ± 43.1	1152.9 ± 398.7	
	20	1580.3 ± 949.2	129.3 ± 24.9	14.4 ± 14.4	79.0 ± 38.0		14.4 ± 14.4
	25	965.4 ± 317.3	116.4 ± 64.1	17.2 ± 8.1	86.2 ± 46.7		4.3 ± 4.3
11 September	15	1034.4 ± 237.1	118.5 ± 32.3		53.9 ± 10.8	1346.9 ± 959.0	
	20	1479.8 ± 815.1	258.6 ± 81.6		64.7 ± 24.9		
	25	836.1 ± 313.4	206.9 ± 46.5		17.2 ± 8.1		
11 October	15	1077.5 ± 86.2	118.5 ± 53.9	21.6 ± 21.6	86.2 ± 64.7	614.2 ± 334.0	10.8 ± 10.8
	20	2665.0 ± 1334.8	194.0 ± 69.3	632.1 ± 311.1	14.4 ± 14.4		
	25	1508.5 ± 490.6	202.6 ± 52.2	194.0 ± 163.6	12.9 ± 5.3		
6 November	15	1260.7 ± 377.1	43.1 ± 21.6	97.0 ± 32.3	237.1 ± 86.2	732.7 ± 86.2	
	20	2241.2 ± 485.7	402.3 ± 57.5	1357.7 ± 455.3	35.9 ± 7.2		
	25	1918.0 ± 602.7	375.0 ± 126.5	724.1 ± 327.3	4.3 ± 4.3		

Table 4 (concl.)

1991

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp.	early instar larvae	Pupae
6 May	15	2068.8 ± 172.4	107.8 ± 21.6		107.8 ± 21.6		
	20	2101.1 ± 1713.2	183.2 ± 53.9	506.4 ± 269.4	161.6 ± 32.3		21.6 ± 0.0
	25	1551.6 ± 585.8	165.2 ± 103.6	344.8 ± 129.9	57.5 ± 47.1		100.6 ± 19.0
21 May	15	754.3 ± 150.9	194.0 ± 21.6	64.7 ± 21.6	64.7 ± 64.7		237.1 ± 64.7
	20	1885.6 ± 1734.8	237.1 ± 86.2	700.4 ± 549.5	269.4 ± 10.8	10.8 ± 10.8	75.4 ± 10.8
	25	2456.7 ± 1267.1	186.8 ± 115.6	287.3 ± 38.0	100.6 ± 19.0		229.9 ± 31.3
	30	840.5 ± 150.9	237.1 ± 21.6	625.0 ± 21.6			86.2 ± 86.2
28 May	15	1357.7 ± 21.5	194.0 ± 21.6	129.3 ± 86.2	129.3 ± 86.2		86.2 ± 86.2
	20	2090.4 ± 1918.0	387.9 ± 172.4	1443.9 ± 560.3	75.4 ± 10.8		97.0 ± 75.4
	25	2140.6 ± 1411.7	416.6 ± 206.1	452.6 ± 150.9	35.9 ± 7.2		86.2 ± 21.6
11 June	15	754.3 ± 107.8	107.8 ± 107.8	344.8 ± 43.1	172.4 ± 43.1		21.6 ± 21.6
	20	1583.9 ± 1239.1	247.8 ± 140.1	1357.7 ± 1185.3	255.0 ± 61.1		
	25	1896.4 ± 1236.0	237.1 ± 195.5	495.7 ± 257.1	57.5 ± 25.9		
25 June	15	625.0 ± 150.9	21.6 ± 21.6	215.5 ± 43.1	150.9 ± 150.9		21.6 ± 21.6
	20	1939.5 ± 1530.1	301.7 ± 194.0	808.1 ± 657.3	140.1 ± 10.8		
	25	1637.8 ± 1271.5	258.6 ± 172.4	635.7 ± 204.7	129.3 ± 43.1		
	30	323.3 ± 150.9	172.4 ± 43.1	646.5 ± 0.0	43.1 ± 0.0		
9 July	15	1249.9 ± 129.3	107.8 ± 21.6	581.9 ± 21.5	172.4 ± 86.2		
	20	1982.6 ± 1767.1	463.3 ± 463.3	366.4 ± 150.9	161.6 ± 118.5		
	25	2187.3 ± 1907.2	355.6 ± 312.5	474.1 ± 172.4	53.9 ± 53.9		
23 July	15	711.2 ± 107.8	21.6 ± 21.6	560.3 ± 43.1	64.7 ± 64.7	107.8 ± 64.7	
	20	2144.2 ± 1821.0	247.8 ± 226.3	183.2 ± 97.0	97.0 ± 53.9		
	25	1400.8 ± 1293.0	237.1 ± 150.9	420.2 ± 32.3	64.7 ± 43.1		
	30	64.7 ± 64.7	43.1 ± 0.0	215.5 ± 43.1			
6 August	15	2111.9 ± 258.6	129.3 ± 43.1	409.5 ± 64.7	86.2 ± 43.1	150.9 ± 150.9	
	20	1573.2 ± 1530.1	204.7 ± 32.3	97.0 ± 32.3	194.0 ± 43.1		
	25	1314.6 ± 1077.5	334.0 ± 140.1	53.9 ± 53.9	21.6 ± 0.0		
20 August	15	1163.7 ± 86.2	258.6 ± 129.3	21.6 ± 21.6	129.3 ± 43.1	129.3 ± 43.1	
	20	2133.5 ± 1724.0	571.1 ± 441.8	10.8 ± 10.8	215.5 ± 43.1		
	25	1971.8 ± 1368.4	226.3 ± 161.6		32.3 ± 10.8		
	30	2155.0 ± 344.8	280.2 ± 21.5	43.1 ± 43.1	64.7 ± 21.6		
6 September	15	754.3 ± 237.1	280.2 ± 64.7	21.6 ± 21.6	86.2 ± 0.0		
	20	1745.6 ± 1487.0	334.0 ± 53.9	32.3 ± 10.8	420.2 ± 118.5		
	25	1508.5 ± 1099.1	334.0 ± 269.4	10.8 ± 10.8	32.3 ± 10.8		
17 September	15	948.2 ± 129.3	129.3 ± 43.1	21.6 ± 21.6	43.1 ± 43.1		
	20	1530.1 ± 1185.3	678.8 ± 441.8		247.8 ± 161.6		
	25	1293.0 ± 1142.2	258.6 ± 215.5		21.6 ± 0.0		
	30	86.2 ± 0.0					
1 October	15	1206.8 ± 905.1	301.7 ± 172.4		237.1 ± 194.0		
	20	1163.7 ± 711.2	549.5 ± 269.4		431.0 ± 21.6		
	25	1630.6 ± 1415.1	176.0 ± 111.3	7.2 ± 7.2	14.4 ± 14.4		
29 October	15	—	—	—	—	—	—
	20	711.2 ± 150.8	1831.8 ± 64.6	495.7 ± 323.3	150.9 ± 150.9		
	25	2780.0 ± 237.0	387.9 ± 172.4	64.7 ± 64.7			

Table 5a. Mean whole-basin densities (no.·m^{-2}) ± SE per sampling date of Chironomus species collected during the open water season (May to November) at 15-, 20-, 25-, and 30-m (± 2.5 m) intervals from the south basin of Amisk Lake (South Amisk), 1988-1991. Blanks indicate densities of 0 animals·m^{-2}. '—' indicates that samples were not collected.

1988

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
25 May	15	64.7 ± 43.1	64.7 ± 43.1	43.1 ± 21.6	21.6 ± 21.6		32.3 ± 10.8
	20	75.4 ± 53.9	215.5 ± 129.3	21.6 ± 21.6			
	25		43.1 ± 0.0				
	30						
13 June	15	43.1 ± 21.6	97.0 ± 10.8	97.0 ± 97.0	75.4 ± 75.4	10.8 ± 10.8	
	20	10.8 ± 10.8	75.4 ± 10.8	10.8 ± 10.8	21.6 ± 21.6		
	25		75.4 ± 53.9	43.1 ± 21.6			
	30			64.7 ± 0.0			
28 June	15	64.7 ± 21.6	21.6 ± 21.6	53.9 ± 32.3	43.1 ± 43.1		
	20		118.5 ± 97.0		21.6 ± 21.6		10.8 ± 10.8
	25	10.8 ± 10.8	43.1 ± 21.6	10.8 ± 10.8		10.8 ± 10.8	
	30			32.3 ± 10.8			
12 July	15	32.3 ± 10.8	86.2 ± 43.1	64.7 ± 64.7	10.8 ± 10.8	775.8 ± 366.4	
	20	10.8 ± 10.8	194.0 ± 129.3	21.6 ± 21.6			
	25	10.8 ± 10.8	21.6 ± 21.6	21.6 ± 21.6		10.8 ± 10.8	
	30			21.6 ± 0.0			
26 July	15	140.1 ± 53.9	86.2 ± 43.1	10.8 ± 10.8	64.7 ± 64.7	2661.4 ± 528.0	
	20	43.1 ± 43.1	107.8 ± 21.6	21.6 ± 21.6			
	25			32.3 ± 32.3			
	30			10.8 ± 10.8			
4 August	15	53.9 ± 53.9	43.1 ± 43.1		10.8 ± 10.8	571.1 ± 377.1	
	20	10.8 ± 10.8	398.7 ± 377.1	75.4 ± 75.4		10.8 ± 10.8	
	25		10.8 ± 10.8	21.6 ± 21.6			
	30						
24 August	15	107.8 ± 43.1	21.6 ± 0.0		10.8 ± 10.8	2176.6 ± 323.3	
	20	21.6 ± 0.0	43.1 ± 43.1		10.8 ± 10.8		
	25		32.3 ± 32.3	64.7 ± 64.7			
	30						
9 September	15	53.9 ± 10.8	53.9 ± 32.3		10.8 ± 10.8	2521.4 ± 366.3	
	20	10.8 ± 10.8	161.6 ± 140.1	10.8 ± 10.8		10.8 ± 10.8	
	25	21.6 ± 21.6	53.9 ± 53.9	10.8 ± 10.8			
	30						
8 October	15	603.4 ± 495.7	161.6 ± 161.6		32.3 ± 32.3	603.4 ± 301.7	
	20	129.3 ± 129.3	140.1 ± 75.4	43.1 ± 21.6		86.2 ± 86.2	
	25	10.8 ± 10.8	75.4 ± 53.9	43.1 ± 21.6			
	30						
4 November	15	3361.8 ± 1034.4	118.5 ± 32.3	10.8 ± 10.8	10.8 ± 10.8		
	20	290.9 ± 10.8	107.8 ± 43.1	10.8 ± 10.8			
	25	150.9 ± 43.1	129.3 ± 0.0	43.1 ± 43.1	10.8 ± 10.8	64.7 ± 64.7	
	30	21.6 ± 21.6				10.8 ± 10.8	

Table 5a. (cont.)

1989

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
12 May	15	2629.1 ± 224.1	517.2 ± 374.6	37.7 ± 30.9	37.7 ± 30.9		53.9 ± 47.0
	20	97.0 ± 28.5	188.6 ± 79.2	21.6 ± 10.8			26.9 ± 21.6
	25			10.8 ± 10.8			
26 May	15	2424.4 ± 268.2	107.8 ± 49.0	5.4 ± 5.4	64.7 ± 41.3		
	20	339.4 ± 26.9	334.0 ± 209.4	48.5 ± 28.3			
	25	21.6 ± 21.6	10.8 ± 10.8	10.8 ± 10.8			
14 June	15	2359.7 ± 655.6	350.2 ± 293.6	32.3 ± 10.8	59.3 ± 33.4		
	20	818.9 ± 478.4	274.8 ± 135.5	16.2 ± 10.3	5.4 ± 5.4		
	25	10.8 ± 10.8	21.6 ± 21.6	32.3 ± 32.3			
24 June	15	2429.8 ± 367.8	366.4 ± 139.7	10.8 ± 6.2	32.3 ± 25.6		
	20	194.0 ± 44.9	366.4 ± 120.3	37.7 ± 13.6	5.4 ± 5.4		
	25		21.6 ± 0.0	10.8 ± 10.8			
12 July	15	1831.8 ± 105.2	220.9 ± 128.5	16.2 ± 10.3	59.3 ± 29.7		
	20	280.2 ± 63.4	339.4 ± 48.5	10.8 ± 6.2			
	25		21.6 ± 21.6				
21 July	15	1573.2 ± 124.7	204.7 ± 133.3	215.5 ± 215.5	43.1 ± 8.8		
	20	932.0 ± 395.9	457.9 ± 172.0		5.4 ± 5.4		
	25	97.0 ± 75.4	53.9 ± 10.8	10.8 ± 10.8			
4 August	15	1777.9 ± 305.8	247.8 ± 116.2	10.8 ± 10.8	16.2 ± 10.3	10.8 ± 10.8	
	20	700.4 ± 313.3	307.1 ± 121.1	5.4 ± 5.4			
	25	10.8 ± 10.8		75.4 ± 75.4			
23 August	15	1384.6 ± 334.6	177.8 ± 94.9	5.4 ± 5.4	26.9 ± 13.6		
	20	307.1 ± 145.2	161.6 ± 59.3				
	25	53.9 ± 53.9	43.1 ± 21.6	86.2 ± 86.2			
8 September	15	926.7 ± 220.5	64.7 ± 23.3		26.9 ± 20.4		
	20	242.4 ± 143.6	183.2 ± 86.9				
	25		10.8 ± 10.8	32.3 ± 32.3			
2 October	15	1675.5 ± 251.1	107.8 ± 24.9				
	20	285.5 ± 144.1	145.5 ± 37.7	5.4 ± 5.4			
	25	32.3 ± 10.8	226.3 ± 204.7	32.3 ± 32.3			
31 October	15	—	—	—	—	—	—
	20	199.3 ± 57.3	355.6 ± 218.6	37.7 ± 10.3		10.8 ± 10.8	
	25						

Table 5a. (cont.)

1990

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
10 May	15	86.2 ± 43.1	97.0 ± 10.8	678.8 ± 614.2	32.3 ± 32.3	53.9 ± 53.9	237.1 ± 107.8
	20	14.4 ± 14.4	244.2 ± 44.0	50.3 ± 17.6			158.0 ± 0.0
	25	2.4 ± 2.4	9.6 ± 7.3	43.1 ± 15.7		2.4 ± 2.4	12.0 ± 7.3
27 May	15	21.6 ± 21.6	107.8 ± 86.2	118.5 ± 32.3	75.4 ± 53.9	32.3 ± 10.8	21.6 ± 0.0
	20		304.0 ± 316.7	158.0 ± 35.2	7.2 ± 8.8	14.4 ± 8.8	21.6 ± 17.6
	25		21.6 ± 10.2	21.6 ± 11.4			4.8 ± 3.2
14 June	15	21.6 ± 21.6	178.3 ± 101.9	64.5 ± 21.4	15.6 ± 6.0	4.8 ± 4.8	
	20		29.5 ± 19.5	71.7 ± 15.6	3.2 ± 3.9	6.4 ± 7.8	
	25		16.7 ± 7.4	33.5 ± 13.5		2.1 ± 1.4	
26 June	15	53.9 ± 32.3	64.7 ± 43.1	64.7 ± 64.7	32.3 ± 32.3	75.4 ± 53.9	
	20	64.7 ± 64.7	136.5 ± 132.0	64.7 ± 8.8			
	25		59.9 ± 39.3	21.6 ± 5.1		2.4 ± 2.4	
11 July	15	129.3 ± 129.3	495.7 ± 495.7	107.8 ± 64.7		3017.0 ± 1357.6	
	20	50.3 ± 14.4	100.6 ± 17.6	122.1 ± 61.6		359.2 ± 158.4	
	25		88.6 ± 34.7	28.7 ± 7.2		225.1 ± 70.3	
20 July	15	64.7 ± 0.0	150.9 ± 43.1	43.1 ± 43.1	32.3 ± 32.3	5258.2 ± 1314.6	
	20		273.0 ± 281.5	201.1 ± 132.0		976.9 ± 26.4	
	25	23.9 ± 19.2	105.4 ± 44.5	31.1 ± 9.6	4.8 ± 3.2	325.6 ± 68.6	
1 August	15	86.2 ± 86.2	183.2 ± 140.1	21.6 ± 21.6	21.6 ± 21.6	4902.6 ± 1756.3	
	20	1120.6 ± 143.5	854.8 ± 827.0	93.4 ± 61.6	14.4 ± 0.0	344.8 ± 0.0	
	25	421.4 ± 82.7	198.7 ± 85.3	40.7 ± 22.6	2.4 ± 2.4	153.2 ± 82.8	
17 August	15	269.4 ± 10.8	765.0 ± 678.8	10.8 ± 10.8		3620.4 ± 2111.9	
	20	632.1 ± 212.0	380.7 ± 167.2	14.4 ± 17.6	35.9 ± 17.6		
	25	682.4 ± 195.5	229.9 ± 71.3	19.2 ± 8.4	14.4 ± 5.1		
12 September	15	1099.1 ± 366.4	172.4 ± 21.6			6281.8 ± 1390.0	
	20	1810.2 ± 675.4	1163.7 ± 1082.1		7.2 ± 8.8		
	25	562.7 ± 136.2	553.1 ± 164.0	47.9 ± 33.8	2.4 ± 2.4		
12 October	15	5646.1 ± 754.3	97.0 ± 53.9	10.8 ± 10.8	10.8 ± 10.8	1971.8 ± 829.7	
	20	4231.0 ± 1009.4	431.0 ± 272.7				
	25	1020.0 ± 217.8	337.6 ± 116.7	21.6 ± 11.9		4.8 ± 4.8	
7 November	15	4029.9 ± 172.4	32.3 ± 10.8		32.3 ± 10.8	1562.4 ± 269.4	
	20	4259.7 ± 1338.7	1206.8 ± 879.8	107.8 ± 44.0	14.4 ± 8.8		7.2 ± 0.0
	25	953.0 ± 201.9	589.0 ± 230.6	4.8 ± 3.2			

Table 5a. (concl.)

1991

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp.	early instar larvae	Pupae
6 May	15	4978.1 ± 280.1	215.5 ± 129.3		86.2 ± 43.1		64.7 ± 21.6
	20	3469.6 ± 1680.9	1346.9 ± 1131.4	269.4 ± 10.8	32.3 ± 32.3		21.6 ± 21.6
	25	3268.4 ± 1810.3	1293.0 ± 622.5	57.5 ± 38.0	7.2 ± 7.2		35.9 ± 25.9
22 May	15	3965.2 ± 258.6	107.8 ± 21.6		21.6 ± 21.6		43.1 ± 0.0
	20	2726.1 ± 1066.7	829.7 ± 441.8	344.8 ± 107.8	10.8 ± 10.8		21.6 ± 21.6
	25	912.3 ± 84.7	323.3 ± 204.8	14.4 ± 7.2			
	30	431.0 ± 172.4	86.2 ± 43.1				
29 May	15	4180.7 ± 689.6	754.3 ± 21.6		21.6 ± 21.6		
	20	4126.8 ± 959.0	1562.4 ± 1433.1	43.1 ± 21.6	10.8 ± 10.8		
	25	1623.4 ± 433.6	323.3 ± 155.4	35.9 ± 25.9			21.6 ± 21.6
13 June	15	4719.5 ± 150.8	64.7 ± 64.7		21.6 ± 21.6		
	20	3264.8 ± 161.6	711.2 ± 431.0	129.3 ± 129.3			
	25	765.0 ± 53.9	808.1 ± 743.5				
26 June	15	3167.9 ± 194.0	107.8 ± 21.6		43.1 ± 43.1		
	20	3738.9 ± 161.6	1023.6 ± 937.4	97.0 ± 97.0	32.3 ± 32.3		
	25	625.0 ± 323.3	808.1 ± 808.1	21.6 ± 0.0			
	30	107.8 ± 64.7	43.1 ± 43.1				
10 July	15	3081.7 ± 21.6	64.7 ± 21.6		21.6 ± 21.6		21.6 ± 21.6
	20	3846.7 ± 312.5	668.1 ± 517.2	43.1 ± 43.1	10.8 ± 10.8		
	25	872.8 ± 635.7	1109.8 ± 1109.8	10.8 ± 10.8			10.8 ± 10.8
24 July	15	2586.0 ± 431.0	948.2 ± 215.5				
	20	2780.0 ± 625.0	1303.8 ± 1066.7	53.9 ± 10.8			
	25	1206.8 ± 668.1	765.0 ± 700.4	53.9 ± 53.9			
	30	474.1 ± 215.5		86.2 ± 0.0			
7 August	15	3534.2 ± 301.7	689.6 ± 344.8		21.6 ± 21.6	21.6 ± 21.6	
	20	2909.3 ± 387.9	1260.7 ± 937.4	43.1 ± 21.6			
	25	1163.7 ± 646.5	290.9 ± 290.9	10.8 ± 10.8			
21 August	15	4094.5 ± 172.4	172.4 ± 86.2				
	20	3458.8 ± 377.1	743.5 ± 355.6	21.6 ± 0.0	10.8 ± 10.8		
	25	980.5 ± 75.4	883.6 ± 862.0	161.6 ± 97.0	10.8 ± 10.8		
	30	43.1 ± 0.0					
7 September	15	4180.7 ± 301.7	258.6 ± 86.2		21.6 ± 21.6		
	20	3674.3 ± 441.8	743.5 ± 441.8	10.8 ± 10.8	10.8 ± 10.8		
	25	1023.6 ± 571.1	1260.7 ± 1260.7	53.9 ± 53.9			
17 September	15	4029.9 ± 280.1	215.5 ± 172.4		43.1 ± 43.1		
	20	3771.3 ± 905.1	571.1 ± 269.4	10.8 ± 10.8			
	25	1217.6 ± 937.4	1120.6 ± 1077.5	21.6 ± 21.6			
	30	53.9 ± 10.8					
2 October	15	4137.6 ± 775.8	215.5 ± 0.0		21.6 ± 21.6		
	20	1551.6 ± 215.5	560.3 ± 474.1	21.6 ± 21.6			
	25	1767.1 ± 754.3	635.7 ± 571.1	10.8 ± 10.8			
	30	107.8 ± 21.6	43.1 ± 0.0				
29 October	15	—	—	—	—	—	—
	20	2025.7 ± 689.6	797.4 ± 107.8	43.1 ± 43.1			
	25	1034.4 ± 560.3	1573.2 ± 883.6				

Table 5b. Mean near-end densities (no.·m^{-2}) ± SE per sampling date of Chironomus species collected during the open water season (May to November) at 20-m (1989-1991) and 25-m (1990-1991) intervals (± 2.5 m) from the south basin of Amisk Lake (South Amisk), 1988-1991. Blanks indicate densities of 0 animals·m^{-2}. '—' indicates that samples were not collected.

1989

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
12 May	20	86.2 ± 64.7	172.4 ± 150.9	21.6 ± 21.6			43.1 ± 43.1
26 May	20	344.8 ± 64.6	183.2 ± 53.9	43.1 ± 43.1			
14 June	20	1497.7 ± 657.3	474.1 ± 172.4	21.6 ± 21.6	10.8 ± 10.8		
24 June	20	194.0 ± 21.6	344.8 ± 237.1	32.3 ± 32.3			
12 July	20	215.5 ± 107.8	280.2 ± 64.7	10.8 ± 10.8			
21 July	20	1357.7 ± 754.3	280.2 ± 129.3		10.8 ± 10.8		
4 August	20	1185.3 ± 344.8	237.1 ± 129.3	10.8 ± 10.8			
23 August	20	484.9 ± 247.8	194.0 ± 86.2				
8 September	20	323.3 ± 301.7	129.3 ± 43.1				
2 October	20	409.5 ± 301.7	107.8 ± 0.0				
31 October	20	290.9 ± 32.3	215.5 ± 150.9	32.3 ± 10.8		21.6 ± 21.6	

Table 5b. (cont.)

1990

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
10 May	20		75.4 ± 53.9	21.6 ± 21.6			21.6 ± 0.0
	25	4.3 ± 4.3	12.9 ± 12.9	12.9 ± 8.6		4.3 ± 4.3	4.3 ± 4.3
27 May	20		387.9 ± 387.9	86.2 ± 43.1	10.8 ± 10.8	10.8 ± 10.8	21.6 ± 21.6
	25		17.2 ± 17.2	12.9 ± 5.3			4.3 ± 4.3
14 June	20		33.4 ± 23.9	86.0 ± 19.1	4.8 ± 4.8	9.6 ± 9.6	
	25		21.5 ± 10.6	17.2 ± 10.6		3.8 ± 2.3	
26 June	20	97.0 ± 97.0	161.6 ± 161.6	10.8 ± 10.8			
	25		99.1 ± 68.0	21.6 ± 0.0		4.3 ± 4.3	
11 July	20	64.7 ± 0.0	64.7 ± 21.6	118.5 ± 75.4		452.6 ± 194.0	
	25		90.5 ± 47.4	17.2 ± 8.1		310.3 ± 111.7	
20 July	20		344.8 ± 344.8	183.2 ± 161.6		808.1 ± 32.3	
	25		51.7 ± 41.8	38.8 ± 15.8	4.3 ± 4.3	353.4 ± 104.8	
1 August	20	1217.6 ± 183.2	1077.5 ± 1012.9	75.4 ± 75.4			
	25	530.1 ± 83.4	224.1 ± 160.1	25.9 ± 8.1	4.3 ± 4.3	103.4 ± 103.4	
17 August	20	743.5 ± 312.5	247.8 ± 204.7	21.6 ± 21.6	43.1 ± 21.6		
	25	883.6 ± 310.1	198.3 ± 78.7	30.2 ± 12.9	12.9 ± 5.3		
12 September	20	2273.5 ± 851.2	1562.4 ± 1325.3		10.8 ± 10.8		
	25	719.8 ± 210.9	435.3 ± 249.8	86.2 ± 57.4	4.3 ± 4.3		
12 October	20	4288.5 ± 1745.6	420.2 ± 334.0				
	25	810.3 ± 191.6	103.4 ± 88.2	30.2 ± 20.0			
7 November	20	2930.8 ± 280.2	1637.8 ± 1077.5	161.6 ± 53.9	10.8 ± 10.8		
	25	935.3 ± 378.1	556.0 ± 430.3	4.3 ± 4.3			

Table 5b. (concl.)

1991

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp.	early instar larvae	Pupae
6 May	20	1788.7 ± 625.0	215.5 ± 129.3	280.2 ± 64.7			
	25	3480.3 ± 3114.0	765.0 ± 571.1	86.2 ± 43.1	10.8 ± 10.8		10.8 ± 10.8
22 May	20	3792.8 ± 172.4	387.9 ± 43.1	452.6 ± 21.6	21.6 ± 21.6		
	25	937.4 ± 140.1	118.5 ± 10.8	10.8 ± 10.8			
29 May	20	5085.8 ± 301.7	129.3 ± 43.1	64.7 ± 64.7	21.6 ± 21.6		
	25	2025.7 ± 280.2	172.4 ± 64.7	53.9 ± 32.3			
13 June	20	3103.2 ± 43.1	280.2 ± 64.7	258.6 ± 0.0			
	25	818.9 ± 215.5	64.7 ± 21.6				
26 June	20	3577.3 ± 991.3	86.2 ± 86.2	194.0 ± 64.7	64.7 ± 21.6		
	25	301.7 ± 172.4		21.6 ± 21.6			
10 July	20	3534.2 ± 129.3	150.9 ± 21.6				
	25	237.1 ± 64.7		21.6 ± 21.6			
24 July	20	3404.9 ± 775.8	237.1 ± 150.9	43.1 ± 0.0			
	25	1874.9 ± 64.6	64.7 ± 21.6	107.8 ± 64.7			
7 August	20	3297.2 ± 107.8	323.3 ± 64.7	21.6 ± 21.6			
	25	517.2 ± 301.7		21.6 ± 21.6			
21 August	20	3835.9 ± 258.6	387.9 ± 0.0	21.6 ± 21.6			
	25	1056.0 ± 668.1	21.6 ± 21.6	258.6 ± 215.5			
7 September	20	4116.1 ± 21.6	301.7 ± 43.1	21.6 ± 21.6	21.6 ± 21.6		
	25	452.6 ± 21.6		107.8 ± 21.6			
17 September	20	2866.2 ± 150.8	301.7 ± 0.0	21.6 ± 21.6			
	25	280.2 ± 64.7	43.1 ± 0.0	43.1 ± 43.1			
2 October	20	1336.1 ± 818.9	86.2 ± 86.2	43.1 ± 0.0			
	25	2521.4 ± 2176.6	64.7 ± 64.7	21.6 ± 21.6			
29 October	20	----	----	----	----	----	----
	25	----	----	----	----	----	----

Table 5c. Mean far-end densities (no.·m^{-2}) ± SE per sampling date of Chironomus species collected during the open water season (May to November) at 20-m (1989-1991) and 25-m (1990-1991) intervals (± 2.5 m) from the south basin of Amisk Lake (South Amisk), 1988-1991. Blanks indicate densities of 0 animals·m^{-2}.

1989

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
12 May	20	107.8 ± 21.6	204.7 ± 10.8	21.6 ± 21.6			10.8 ± 10.8
26 May	20	334.0 ± 10.8	484.9 ± 463.3	53.9 ± 53.9			
14 June	20	140.1 ± 140.1	75.4 ± 32.3	10.8 ± 10.8			
24 June	20	194.0 ± 107.8	387.9 ± 172.4	43.1 ± 0.0	10.8 ± 10.8		
12 July	20	344.8 ± 64.6	398.7 ± 53.9	10.8 ± 10.8			
21 July	20	506.4 ± 97.0	635.7 ± 312.5				
4 August	20	215.5 ± 0.0	377.1 ± 247.8				
23 August	20	129.3 ± 43.1	129.3 ± 107.8				
8 September	20	161.6 ± 140.1	237.1 ± 194.0				
2 October	20	161.6 ± 53.9	183.2 ± 75.4	10.8 ± 10.8			
31 October	20	107.8 ± 43.1	495.7 ± 474.1	43.1 ± 21.6			

Table 5c. (cont.)

1990

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
10 May	20	43.1 ± 43.1	581.9 ± 64.6	107.8 ± 107.8			431.0 ± 172.4
	25		5.4 ± 5.4	80.8 ± 22.2			21.6 ± 15.2
27 May	20		136.2 ± 136.2	301.7 ± 43.1		21.6 ± 21.6	21.6 ± 21.6
	25		26.9 ± 10.3	32.3 ± 25.6			5.4 ± 5.4
14 June	20		21.6 ± 21.6	43.1 ± 0.0			
	25		10.8 ± 10.8	53.9 ± 25.6			
26 June	20		86.2 ± 0.0	172.4 ± 43.1			
	25		10.8 ± 10.8	21.6 ± 12.4			
11 July	20	21.6 ± 21.6	172.4 ± 86.2	129.3 ± 86.2		172.4 ± 0.0	
	25		86.2 ± 59.0	43.1 ± 8.8		118.5 ± 45.3	
20 July	20		129.3 ± 129.3	237.1 ± 64.7		1314.6 ± 193.9	
	25	53.9 ± 40.8	172.4 ± 79.2	21.6 ± 8.8	5.4 ± 5.4	290.9 ± 95.8	
1 August	20	926.7 ± 840.5	409.5 ± 21.5	129.3 ± 43.1	43.1 ± 43.1	1034.4 ± 1034.4	
	25	285.5 ± 135.5	167.0 ± 18.4	59.3 ± 52.3		215.5 ± 144.8	
17 August	20	409.5 ± 194.0	646.5 ± 215.5		21.6 ± 21.6		
	25	431.0 ± 176.6	269.4 ± 138.7	5.4 ± 5.4	16.2 ± 10.3		
12 September	20	883.6 ± 194.0	366.4 ± 21.6				
	25	366.4 ± 118.4	700.4 ± 210.5				
12 October	20	4116.1 ± 280.1	452.6 ± 150.9				
	25	1282.2 ± 426.9	630.3 ± 131.5	10.8 ± 10.8		10.8 ± 10.8	
7 November	20	6917.6 ± 581.9	344.8 ± 86.2		21.6 ± 21.6		21.6 ± 21.6
	25	975.1 ± 77.4	630.3 ± 96.9	5.4 ± 5.4			

Table 5c. (concl.)

1991

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp	early instar larvae	Pupae
6 May	20	5150.5 ± 1314.6	2478.3 ± 409.4	258.6 ± 43.1	64.7 ± 64.7		43.1 ± 0.0
	25	2844.6 ± 431.0	2349.0 ± 366.4				86.2 ± 86.2
22 May	20	1659.4 ± 409.5	1271.5 ± 495.7	237.1 ± 194.0			43.1 ± 0.0
	25	862.0 ± 86.2	732.7 ± 560.3	21.6 ± 21.6			
29 May	20	3167.9 ± 366.4	2995.5 ± 194.0	21.6 ± 21.6			
	25	818.9 ± 474.1	625.0 ± 581.9				64.7 ± 64.7
13 June	20	3426.5 ± 581.9	1142.2 ± 237.1				
	25	711.2 ± 64.7	1551.6 ± 818.9				
26 June	20	3900.6 ± 452.6	1961.1 ± 237.0				
	25	948.2 ± 43.1	1616.3 ± 452.6	21.6 ± 21.6			
10 July	20	4159.2 ± 797.4	1185.3 ± 323.3	86.2 ± 86.2	21.6 ± 21.6		
	25	1508.5 ± 560.3	2219.7 ± 107.8				21.6 ± 21.6
24 July	20	2155.0 ± 0.0	2370.5 ± 43.1	64.7 ± 21.6			
	25	538.8 ± 64.6	1465.4 ± 431.0				
7 August	20	2521.4 ± 323.3	2198.1 ± 517.2	64.7 ± 21.6			
	25	1810.2 ± 215.5	581.9 ± 107.8				
21 August	20	3081.7 ± 323.3	1099.1 ± 581.9	21.6 ± 21.6	21.6 ± 21.6		
	25	905.1 ± 603.4	1745.6 ± 1271.5	64.7 ± 21.6	21.6 ± 21.6		
7 September	20	3232.5 ± 387.9	1185.3 ± 21.5				
	25	1594.7 ± 646.5	2521.4 ± 280.1				
17 September	20	4676.4 ± 668.1	840.5 ± 107.8				
	25	2155.0 ± 129.3	2198.1 ± 948.2				
2 October	20	1767.1 ± 86.2	1034.4 ± 0.0				
	25	1012.9 ± 969.8	1206.8 ± 948.2				
29 October	20	2025.7 ± 689.6	797.4 ± 107.8	43.1 ± 43.1			
	25	1034.4 ± 560.3	1573.2 ± 883.6				

Table 6. Mean whole-basin densities (no.·m^{-2}) ± SE per sampling date of Chironomus species collected during the open water season (May to November) at 15-, 20-, and 25-m (± 2.5 m) intervals from the south basin of Baptiste Lake (South Baptiste), 1988-1991. Blanks indicate densities of 0 animals·m^{-2}. '-----' indicates that samples were not collected.

1988

Date	Depth (m)	C. anthracinus	C. cucini	C. plumosus gp.
15 May	15	21.6 ± 21.6	301.7 ± 215.5	194.0 ± 194.0
	20		21.6 ± 21.6	64.7 ± 64.7
	25			
19 June	15	21.6 ± 0.0	366.4 ± 258.6	301.7 ± 215.5
	20		43.1 ± 21.6	107.8 ± 21.6
	25		21.6 ± 21.6	43.1 ± 0.0
9 July	15	10.8 ± 10.8	86.2 ± 0.0	312.5 ± 97.0
	20		43.1 ± 43.1	118.5 ± 32.3
	25			86.2 ± 0.0
28 July	15		204.7 ± 53.9	431.0 ± 0.0
	20		10.8 ± 10.8	53.9 ± 10.8
	25			21.6 ± 0.0
10 August	15	75.4 ± 75.4	172.4 ± 43.1	323.3 ± 107.8
	20			75.4 ± 10.8
	25			64.7 ± 0.0
25 August	15	10.8 ± 10.8	64.7 ± 21.6	258.6 ± 86.2
	20		21.6 ± 0.0	140.1 ± 32.3
	25			21.6 ± 0.0
11 September	15		387.9 ± 43.1	301.7 ± 0.0
	20		10.8 ± 10.8	107.8 ± 21.6
	25			32.3 ± 32.3
9 October	15		86.2 ± 43.1	97.0 ± 32.3
	20			97.0 ± 75.4
	25			21.6 ± 0.0
5 November	15	226.3 ± 226.3	549.5 ± 247.8	161.6 ± 53.9
	20		10.8 ± 10.8	64.7 ± 0.0
	25		10.8 ± 10.8	32.3 ± 32.3

Table 6 (cont.)

1990 Date	Depth (m)	C. cucini	C. decorus	C. plumosus gp.
11 May	15	226.3 ± 226.3		183.2 ± 161.6
	20	21.6 ± 21.6		14.4 ± 14.4
	25	4.8 ± 3.2		12.0 ± 5.2
29 May	15	420.2 ± 398.7		150.9 ± 150.9
	20	21.6 ± 21.6		7.2 ± 7.2
	25	2.4 ± 2.4		7.2 ± 5.1
15 June	15	678.1 ± 678.1		181.5 ± 143.3
	20	6.4 ± 6.4	7.2 ± 7.2	6.4 ± 6.4
	25	7.6 ± 1.9		19.1 ± 12.1
27 June	15	43.1 ± 43.1		21.6 ± 21.6
	20	28.7 ± 19.0		
	25			9.6 ± 3.8
12 July	15	64.7 ± 64.7		64.7 ± 64.7
	20	50.3 ± 50.3		28.7 ± 19.0
	25	4.8 ± 4.8		9.6 ± 5.2
23 July	15	53.9 ± 53.9		107.8 ± 107.8
	20	7.2 ± 7.2		28.7 ± 28.7
	25			
7 August	15	107.8 ± 86.2		43.1 ± 43.1
	20	14.4 ± 14.4		21.6 ± 12.4
	25			7.2 ± 3.6
20 August	15	75.4 ± 32.3		32.3 ± 32.3
	20			43.1 ± 21.6
	25	2.4 ± 2.4		7.2 ± 5.1
14 September	15	86.2 ± 86.2		86.2 ± 64.7
	20	43.1 ± 32.9		14.4 ± 7.2
	25			7.2 ± 5.1
13 October	15	247.8 ± 247.8		86.2 ± 43.1
	20	7.2 ± 7.2		7.2 ± 7.2
	25			14.4 ± 9.5
8 November	15	172.4 ± 129.3		75.4 ± 53.9
	20			7.2 ± 7.2
	25	7.2 ± 7.2		7.2 ± 7.2

Table 6 (concl.)

1991

Date	Depth (m)	C. anthracinus	C. cucini	C. decorus	C. plumosus gp.
9 May	15	21.6 ± 21.6	323.3 ± 107.8		215.5 ± 43.1
	20		43.1 ± 43.1		
	25				10.8 ± 10.8
23 May	15		172.4 ± 43.1		64.7 ± 64.7
	20		53.9 ± 32.3		10.8 ± 10.8
	25				21.6 ± 0.0
31 May	15		129.3 ± 43.1		43.1 ± 43.1
	20		21.6 ± 21.6		21.6 ± 21.6
	25				10.8 ± 10.8
14 June	15		107.8 ± 64.7		43.1 ± 0.0
	20			10.8 ± 10.8	10.8 ± 10.8
	25				
28 June	15		150.9 ± 21.6		129.3 ± 86.2
	20				
	25				21.6 ± 21.6
8 July	15		150.9 ± 21.6		107.8 ± 21.6
	20		32.3 ± 32.3		
	25				
26 July	15		107.8 ± 21.6		21.6 ± 21.6
	20		32.3 ± 32.3		
	25				10.8 ± 10.8
8 August	15	14.4 ± 14.4	186.8 ± 38.0		100.6 ± 38.0
	20				10.8 ± 10.8
	25				
23 August	15		194.0 ± 107.7		129.3 ± 43.1
	20		21.6 ± 21.6		32.3 ± 32.3
	25				
8 September	15		64.7 ± 64.7		194.0 ± 107.7
	20		53.9 ± 53.9		
	25				
18 September	15		107.8 ± 64.7		43.1 ± 0.0
	20		43.1 ± 43.1		
	25				
30 October	15	—	—	—	—
	20				10.8 ± 10.8
	25				

Appendix D: Estimated biomasses of Chironomus species and other macroinvertebrate taxa and mean Chironomus spp. larval and pupal weights in North and South Amisk and South Baptiste, 1988-1991.

Table 1a. Mean Chironomus spp. larval and pupal biomasses ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the north basin of Amisk Lake (North Amisk), 1988-1991. Blanks indicate no larvae or pupae were collected.

Date	C. anthracinus	C. cucini	C.decorus	C. plumosus gp.	Early instar larvae	Pupae
1988						
16 May		32.2 ± 24.9	2.3 ± 2.3			23.4 ± 23.4
10 June			29.0 ± 5.3			
24 June		14.1 ± 14.1	81.9 ± 16.9			
10 July	24.9 ± 24.9		79.7 ± 26.7		1.2 ± 0.9	
21 July		32.1 ± 32.1	43.5 ± 3.7		3.8 ± 3.5	
2 August			26.4 ± 5.6		24.9 ± 20.2	
23 August		40.7 ± 40.7	12.7 ± 12.7		9.1 ± 9.1	
8 September		18.3 ± 18.3	3.4 ± 3.4		13.5 ± 2.1	
7 October	7.3 ± 7.3	21.5 ± 20.4		47.3 ± 47.3	16.7 ± 16.7	
3 November	410.0 ± 201.6	52.2 ± 52.2	5.6 ± 5.6			
1989						
7 May	307.9 ± 158.4	9.4 ± 9.4	10.7 ± 10.7	101.1 ± 101.1		
25 May	351.3 ± 106.5		249.7 ± 40.7			
12 June	198.4 ± 198.4		222.6 ± 198.0			
23 June	1315.6 ± 842.3	50.8 ± 25.4	585.4 ± 214.1	57.7 ± 57.7		
10 July	231.8 ± 116.9		569.2 ± 128.7	31.8 ± 31.8		
20 July	596.3 ± 516.3	85.6 ± 85.6	154.5 ± 22.3	33.7 ± 33.7		
3 August	1973.9 ± 1915.6	140.1 ± 140.1	183.0 ± 158.7	25.8 ± 25.8		
21 August	546.3 ± 95.3	65.9 ± 65.9				
7 September	350.2 ± 345.5	71.1 ± 71.1				
1 October	358.4 ± 255.9	55.8 ± 55.8		39.9 ± 39.9		
31 October	666.9 ± 308.8	107.9 ± 16.1	34.1 ± 24.8	115.2 ± 41.9		

Table 1a (concl.)

Date	C. anthracinus	C. cucini	C.decorus	C. plumosus gp.	Early instar larvae	Pupae
1990						
9 May		37.8 ± 37.8	69.6 ± 51.1	265.1 ± 133.5	1.2 ± 1.2	66.7 ± 27.4
26 May	1.2 ± 1.2		46.9 ± 46.9	2.6 ± 2.6	3.1 ± 3.1	76.8 ± 76.8
11 June		99.5 ± 51.1	206.5 ± 165.4	320.8 ± 320.8	4.5 ± 4.5	
23 June		15.8 ± 15.8	182.0 ± 117.8	53.0 ± 53.0		
10 July	7.2 ± 7.2	66.7 ± 64.9	511.0 ± 120.3	150.9 ± 97.6	37.8 ± 8.2	
19 July		172.5 ± 162.8	429.4 ± 186.7	113.7 ± 37.5	202.2 ± 126.0	
3 August	163.1 ± 30.0	25.5 ± 7.3	155.5 ± 116.2	38.8 ± 38.8	377.6 ± 374.1	
16 August	1217.9 ± 581.3	113.3 ± 95.4	22.0 ± 22.0			
11 September	652.7 ± 488.9	117.5 ± 49.8		112.1 ± 98.0		
11 October	1863.1 ± 1091.4	235.6 ± 116.6		21.5 ± 21.5	12.7 ± 12.7	
6 November	3191.1 ± 2325.0	290.4 ± 104.3	335.9 ± 292.2			
1991						
6 May	3442.8 ± 935.8	361.9 ± 214.7	284.1 ± 103.7	180.0 ± 138.1		145.0 ± 30.3
21 May	5218.7 ± 2378.8	429.2 ± 248.8	295.4 ± 45.2	491.2 ± 128.3		411.4 ± 57.7
28 May	4909.1 ± 2995.5	893.7 ± 409.3	436.4 ± 154.9	102.6 ± 46.8		146.1 ± 41.7
11 June	4599.2 ± 2899.9	497.3 ± 413.8	617.7 ± 322.7	241.2 ± 161.7		
25 June	4149.4 ± 3290.7	633.6 ± 444.6	769.5 ± 356.8	385.3 ± 44.4		
9 July	5831.3 ± 4771.5	760.0 ± 660.3	730.5 ± 355.9	90.6 ± 90.6		
23 July	3862.2 ± 3561.2	508.2 ± 322.7	674.7 ± 18.2	84.1 ± 84.1		
6 August	4040.4 ± 3247.6	863.3 ± 399.9	85.4 ± 85.4	19.2 ± 15.1		
20 August	5615.6 ± 3687.7	584.8 ± 345.7		58.8 ± 53.8		
6 September	4572.5 ± 3526.2	921.2 ± 746.8	13.2 ± 13.2	93.6 ± 76.3		
17 September	3930.1 ± 3518.0	522.6 ± 481.2		58.3 ± 50.4		
2 October	4477.4 ± 3960.4	434.5 ± 218.5	1.4 ± 1.4	103.8 ± 103.8		
29 October	7781.0 ± 707.2	949.6 ± 399.8	33.1 ± 33.1			

Table 1b. Mean whole-basin Chironomus spp. larval and pupal biomasses ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the south basin of Amisk Lake (South Amisk), 1988-1991. Blanks indicate no larvae or pupae were collected.

Date	C. anthracinus	C. cucini	C. decorus	C. plumosus gp.	Early instar larvae	Pupae
1988						
24 May		94.7 ± 34.9				
14 June		154.2 ± 95.5	54.1 ± 36.5			
28 June	23.9 ± 23.9	52.2 ± 45.7	11.4 ± 11.4			
12 July	14.2 ± 14.2	51.7 ± 51.7	23.2 ± 23.2		0.3 ± 0.3	
26 July			38.0 ± 38.0			
4 August		7.5 ± 7.5	24.2 ± 24.2			
24 August		55.2 ± 55.2	97.3 ± 97.3			
9 September	16.9 ± 16.9	162.5 ± 162.5	16.9 ± 16.9	38.7 ± 38.7		
8 October	12.5 ± 12.5	134.1 ± 134.1	37.7 ± 25.6			
4 November	76.2 ± 5.0	87.2 ± 58.8	21.7 ± 21.7	22.9 ± 22.9	11.3 ± 11.3	
1989						
12 May			6.6 ± 6.6			
26 May	18.2 ± 18.2	26.8 ± 26.8	10.6 ± 10.6			
14 June	16.6 ± 16.6	14.1 ± 14.1	41.5 ± 41.5			
24 June		7.3 ± 0.3	15.5 ± 15.5			
12 July		35.3 ± 35.3				
21 July	248.1 ± 187.4	131.3 ± 38.1	15.1 ± 15.1			
4 August	21.2 ± 21.2		97.7 ± 41.5			
23 August	93.2 ± 93.2	77.5 ± 50.3	105.2 ± 105.2			
8 September		12.3 ± 12.3	46.9 ± 46.9			
2 October	40.4 ± 19.6	399.5 ± 399.5	57.7 ± 57.7			
31 October						

Table 1b (concl.)

Date	C. anthracinus	C. cucini	C.decorus	C. plumosus gp.	Early instar larvae	Pupae
1990						
10 May	21.8 ± 21.8	10.3 ± 10.3	4.3 ± 3.3			9.0 ± 6.0
27 May		47.1 ± 20.9	6.5 ± 6.5			23.7 ± 14.0
14 June		67.1 ± 39.0	32.4 ± 20.0		0.4 ± 0.4	
26 June		214.5 ± 190.7	10.3 ± 5.9		0.2 ± 0.2	
11 July		131.8 ± 119.8	45.8 ± 13.4		33.9 ± 9.1	
20 July	10.6 ± 10.6	72.0 ± 53.0	41.3 ± 17.1		81.3 ± 25.7	
1 August	119.7 ± 60.1	170.9 ± 152.1	32.1 ± 14.3	0.7 ± 0.7	90.0 ± 83.7	
17 August	326.3 ± 115.3	168.0 ± 69.4	15.2 ± 15.2	25.4 ± 23.5		
12 September	252.5 ± 78.6	118.8 ± 68.8	41.0 ± 41.0	4.0 ± 4.0		
12 October	378.1 ± 143.2	54.6 ± 31.6	49.3 ± 39.1			
7 November	679.7 ± 290.9	319.3 ± 257.8	9.2 ± 6.4			
1991						
6 May	3280.8 ± 1925.1	1297.5 ± 729.2	11.2 ± 9.9	10.3 ± 10.3		42.2 ± 29.4
22 May	1072.4 ± 123.6	431.5 ± 313.8	2.5 ± 1.5			
29 May	1454.9 ± 392.0	344.1 ± 193.5	6.1 ± 5.1			21.0 ± 21.0
13 June	1392.6 ± 66.1	1218.6 ± 1120.2				
26 June	1128.8 ± 594.5	1404.9 ± 1404.9	33.6 ± 1.0			
10 July	1842.2 ± 1353.3	2178.5 ± 2178.5	1.5 ± 1.5			12.9 ± 12.9
24 July	2239.0 ± 962.9	1324.1 ± 1189.0	39.6 ± 39.6			
7 August	2288.5 ± 1105.1	573.1 ± 573.1	2.3 ± 2.3			
21 August	1493.8 ± 304.2	1634.8 ± 1597.3	116.6 ± 80.9	4.2 ± 4.2		
7 September	1920.1 ± 947.1	2637.9 ± 2637.9	68.3 ± 68.3			
17 September	1557.6 ± 1070.8	1957.3 ± 1925.4	31.8 ± 31.8			
2 October	2487.7 ± 996.8	1243.5 ± 1143.6	15.7 ± 15.7			
29 October	886.3 ± 413.8	1656.8 ± 858.4				

Table 1c. Mean near- and far-end Chironomus spp. larval and pupal biomasses ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the south basin of Amisk Lake (South Amisk), 1990-1991. Blanks indicate no larvae or pupae were collected.

Date	C. anthracinus	C. cucini	C.decorus	C. plumosus gp.	Early instar larvae	Pupae
1990 (near end)						
10 May	43.5 ± 43.5	20.5 ± 20.5				12.7 ± 12.7
27 May		46.5 ± 46.5	13.0 ± 13.0			27.0 ± 27.0
14 June		61.4 ± 61.4	16.3 ± 16.3		0.8 ± 0.8	
26 June		392.1 ± 392.1	20.5 ± 1.2		0.4 ± 0.4	
11 July		247.8 ± 242.8	28.1 ± 0.6		46.3 ± 0.6	
20 July		113.3 ± 113.3	19.6 ± 19.6		118.6 ± 32.1	
1 August	130.9 ± 130.9	313.6 ± 312.7	53.6 ± 13.5	1.3 ± 1.3	170.3 ± 170.3	
17 August	409.0 ± 151.7	170.3 ± 73.9	30.3 ± 30.3	2.8 ± 0.4		
12 September	332.9 ± 79.7	141.6 ± 141.3	81.9 ± 81.9	7.9 ± 7.9		
12 October	241.1 ± 57.9	0.9 ± 0.9	98.6 ± 65.5			
7 November	924.7 ± 622.5	546.3 ± 539.6	13.5 ± 13.5			
1990 (far end)						
10 May			8.6 ± 5.4			5.3 ± 5.3
27 May		47.8 ± 21.4				20.5 ± 20.5
14 June		72.8 ± 72.8	48.5 ± 40.3			
26 June		36.9 ± 36.9				
11 July		15.8 ± 15.8	63.5 ± 21.2		21.5 ± 13.6	
20 July	21.2 ± 21.2	30.6 ± 24.2	62.9 ± 21.0		44.0 ± 12.3	
1 August	108.6 ± 65.8	28.1 ± 18.2	10.6 ± 10.6		9.7 ± 9.7	
17 August	243.7 ± 207.6	165.7 ± 153.1		47.9 ± 47.9		
12 September	172.0 ± 133.4	96.1 ± 86.2				
12 October	515.2 ± 286.6	108.3 ± 14.8				
7 November	434.6 ± 9.4	92.3 ± 67.1	5.0 ± 5.0			

Table 1c (concl.)

Date	C. anthracinus	C. cucini	C.decorus	C. plumosus gp.	Early instar larvae	Pupae
1991 (near end)						
6 May	3560.6 ± 3298.9	660.5 ± 614.7	16.9 ± 14.2	15.4 ± 15.4		13.9 ± 13.9
22 May	1124.5 ± 194.0	118.4 ± 37.2	1.2 ± 1.2			
29 May	1838.9 ± 136.7	151.5 ± 32.8	9.1 ± 7.0			
13 June	1458.7 ± 255.9	98.5 ± 11.7				
26 June	534.3 ± 329.7		34.6 ± 34.6			
10 July	488.9 ± 204.0		2.9 ± 2.9			
24 July	3201.9 ± 249.4	135.1 ± 14.4	79.1 ± 62.7			
7 August	1183.5 ± 707.5		4.7 ± 4.7			
21 August	1798.0 ± 1003.2	37.5 ± 37.5	197.5 ± 136.6			
7 September	973.0 ± 10.0		136.6 ± 1.2			
17 September	486.8 ± 78.8	31.9 ± 19.6	63.6 ± 63.6			
2 October	3484.4 ± 2900.0	99.9 ± 99.9	31.4 ± 31.4			
1991 (far end)						
6 May	2721.2 ± 346.7	2571.5 ± 660.0				98.8 ± 98.8
22 May	968.0 ± 14.4	1057.7 ± 731.2	5.3 ± 5.3			
29 May	687.0 ± 286.0	729.2 ± 704.6				63.0 ± 63.0
13 June	1326.5 ± 12.3	2338.8 ± 1119.0				
26 June	1723.3 ± 239.2	2809.8 ± 1206.0	32.5 ± 32.5			
10 July	3195.5 ± 1234.2	4356.9 ± 106.1				25.8 ± 25.8
24 July	1276.1 ± 130.7	2513.2 ± 833.2				
7 August	3393.6 ± 380.1	1146.2 ± 298.6				
21 August	1189.6 ± 646.2	3232.1 ± 2460.1	35.8 ± 23.4	8.5 ± 8.5		
7 September	2867.2 ± 1198.4	5275.7 ± 1035.5				
17 September	2628.3 ± 49.2	3882.7 ± 1896.2				
2 October	1490.9 ± 1383.6	2387.1 ± 1992.7				
29 October	886.3 ± 413.8	1656.8 ± 858.4				

Table 1d. Mean Chironomus spp. larval and pupal biomasses ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the south basin of Baptiste Lake (South Baptiste), 1988-1991. Blanks indicate no larvae or pupae were collected.

Date	C. cucini	C. plumosus group
1988		
15 May		
19 June	64.0 ± 64.0	196.2 ± 6.0
9 July		374.4 ± 78.1
28 July		87.9 ± 24.6
10 August		308.8 ± 33.3
25 August		89.1 ± 0.6
11 September		176.6 ± 176.6
9 October		94.2 ± 39.4
5 November	17.4 ± 17.4	145.4 ± 145.4
1989		
14 May		
27 May		
16 June		
30 June	21.1 ± 21.1	
14 July		37.7 ± 37.7
27 July		
8 August		
28 August	1.6 ± 1.6	
9 September		
4 October		
3 November		42.2 ± 42.2

Table 1d (concl.)

Date	C. cucini	C. plumosus group
1990		
11 May	29.3 ± 19.5	152.7 ± 14.6
29 May	19.1 ± 11.1	193.2 ± 59.9
15 June	23.7 ± 5.1	135.8 ± 53.6
27 June		182.7 ± 18.0
12 July	20.0 ± 11.6	154.8 ± 22.1
23 July		
7 August		144.8 ± 19.1
20 August	22.0 ± 10.4	75.9 ± 2.2
14 September	31.8 ± 18.4	243.6 ± 85.6
13 October		165.3 ± 25.8
8 November	42.8 ± 34.9	66.5 ± 54.3
1991		
9 May		254.7 ± 98.4
23 May		220.7 ± 41.9
31 May		65.6 ± 0.0
14 June		
28 June		668.8 ± 0.0
8 July		
26 July		262.6 ± 0.0
8 August		
23 August		
8 September		
18 September		
30 October		

Table 2a. Mean Chironomus spp., other taxa and total macroinvertebrate biomasses ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the north basin of Amisk Lake (North Amisk), 1988-1991. Blanks indicate no macroinvertebrates were collected.

Date	Total Chironomus spp. Biomass	Other Taxa Biomass	Total Macroinvertebrate Biomass
1988			
16 May	58.0 ± 53.3	58.5 ± 31.5	116.5 ± 71.0
10 June	29.0 ± 17.3	7.6 ± 7.6	36.6 ± 25.4
24 June	96.0 ± 43.8	9.5 ± 9.5	105.5 ± 45.5
10 July	105.8 ± 37.6		105.8 ± 37.6
21 July	79.4 ± 25.4	5.7 ± 5.7	85.1 ± 28.6
2 August	51.3 ± 21.1		51.3 ± 23.2
23 August	62.6 ± 39.6	43.6 ± 29.3	106.2 ± 67.2
8 September	35.2 ± 23.1	38.1 ± 18.5	73.3 ± 23.1
7 October	92.9 ± 55.6	19.2 ± 11.5	112.1 ± 72.9
3 November	467.8 ± 168.9	56.9 ± 8.6	524.6 ± 185.3
1989			
7 May	429.1 ± 139.8	107.6 ± 34.4	536.7 ± 172.4
25 May	601.0 ± 173.5	150.5 ± 17.6	751.4 ± 185.4
12 June	421.0 ± 338.9	78.1 ± 18.7	499.1 ± 383.1
23 June	2009.6 ± 658.9	29.4 ± 12.0	2039.1 ± 715.8
10 July	832.8 ± 129.0	36.0 ± 14.1	868.8 ± 129.8
20 July	870.0 ± 524.7	17.5 ± 15.6	887.5 ± 594.0
3 August	2322.8 ± 1133.4	51.7 ± 17.7	2374.5 ± 1265.2
21 August	612.2 ± 133.8	19.9 ± 18.2	632.1 ± 146.7
7 September	421.3 ± 241.3	15.0 ± 7.9	436.3 ± 265.7
1 October	454.1 ± 172.4	13.1 ± 4.6	467.2 ± 193.5
31 October	924.1 ± 229.6	64.8 ± 36.6	988.9 ± 230.0
1990			
9 May	440.4 ± 149.3	63.5 ± 16.5	503.9 ± 157.8
26 May	130.6 ± 73.4	60.0 ± 19.9	190.5 ± 85.3
11 June	631.3 ± 430.7	27.5 ± 11.4	658.8 ± 466.1
23 June	250.9 ± 101.0	7.8 ± 7.1	258.6 ± 110.4
10 July	773.6 ± 166.7	46.7 ± 20.1	820.3 ± 166.3
19 July	917.8 ± 296.9	61.7 ± 30.2	979.5 ± 357.6
3 August	760.5 ± 162.8	18.4 ± 14.0	779.0 ± 186.2
16 August	1353.2 ± 546.7	4.4 ± 4.4	1357.5 ± 607.3
11 September	882.3 ± 329.1	50.1 ± 37.9	932.4 ± 397.9
11 October	2133.0 ± 745.4	41.1 ± 13.5	2174.1 ± 818.8
6 November	3817.4 ± 1631.9	54.6 ± 5.3	3872.0 ± 1804.7

Table 2a (concl.)

Date	Total *Chironomus* spp. Biomass	Other Taxa Biomass	Total Macroinvertebrate Biomass
1991			
6 May	3360.3 ± 535.9	49.6 ± 15.8	3409.9 ± 582.0
21 May	4649.4 ± 1106.8	38.8 ± 13.6	4688.2 ± 1228.0
28 May	3313.3 ± 579.0	79.7 ± 43.2	3393.0 ± 624.6
11 June	2642.3 ± 394.4	102.6 ± 25.2	2744.9 ± 415.7
25 June	5937.8 ± 1979.0	80.8 ± 46.1	6018.6 ± 2146.6
9 July	7412.3 ± 3115.2	99.7 ± 42.3	7512.0 ± 3476.8
23 July	5129.2 ± 2302.6	41.5 ± 17.2	5170.7 ± 2555.3
6 August	5008.3 ± 2481.5	21.7 ± 9.7	5030.0 ± 2739.1
20 August	6259.2 ± 2355.7	64.8 ± 15.0	6324.0 ± 2608.0
6 September	5600.5 ± 2695.5	61.7 ± 27.9	5662.2 ± 2990.7
17 September	4510.9 ± 2382.0	28.1 ± 15.5	4539.1 ± 2621.4
2 October	4994.2 ± 2473.6	23.6 ± 13.7	5017.8 ± 2741.7
29 October	8763.7 ± 1140.1	5.8 ± 1.9	8769.5 ± 1255.5

Table 2b. Mean Chironomus spp., other taxa and total macroinvertebrate biomasses ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the south basin of Amisk Lake (South Amisk), 1988-1991. Blanks indicate no macroinvertebrates were collected.

Date	Total Chironomus spp. Biomass	Other Taxa Biomass	Total Macroinvertebrate Biomass
1988			
24 May	94.7 ± 31.9	37.7 ± 21.8	132.3 ± 51.6
14 June	208.2 ± 104.2	68.0 ± 30.1	276.3 ± 1.9
28 June	87.5 ± 10.4	4.7 ± 1.3	92.2 ± 10.7
12 July	89.4 ± 71.3	7.4 ± 7.4	96.8 ± 77.8
26 July	38.0 ± 38.0		38.0 ± 38.0
4 August	31.7 ± 22.8	23.9 ± 23.9	55.6 ± 48.5
24 August	152.5 ± 45.1	22.5 ± 18.5	175.0 ± 57.0
9 September	234.9 ± 173.4	19.6 ± 15.2	254.5 ± 206.0
8 October	184.2 ± 118.4	24.4 ± 6.0	208.6 ± 133.7
4 November	219.2 ± 72.3	28.0 ± 6.6	247.2 ± 83.4
1989			
12 May	6.6 ± 6.6	10.8 ± 10.8	17.4 ± 10.8
26 May	55.5 ± 33.9	18.3 ± 13.7	73.8 ± 48.2
14 June	72.1 ± 7.3	3.9 ± 3.9	76.0 ± 8.0
24 June	22.9 ± 18.5	21.2 ± 17.1	44.0 ± 18.8
12 July	35.3 ± 35.3	21.8 ± 15.5	57.1 ± 34.5
21 July	394.5 ± 124.4	81.1 ± 28.6	475.6 ± 151.0
4 August	119.0 ± 58.3	1.8 ± 1.8	120.8 ± 65.9
23 August	275.9 ± 144.2	14.7 ± 13.2	290.6 ± 166.1
8 September	59.2 ± 59.2	14.4 ± 9.1	73.6 ± 67.6
2 October	497.6 ± 280.5	37.5 ± 13.0	535.1 ± 315.0
31 October		13.6 ± 13.6	13.6 ± 0.3
1990			
10 May	45.4 ± 27.7	11.6 ± 5.6	56.9 ± 29.3
27 May	77.4 ± 30.8	33.9 ± 10.0	111.2 ± 35.9
14 June	99.9 ± 49.1	68.1 ± 20.1	168.0 ± 51.7
26 June	225.0 ± 181.1	80.4 ± 58.6	305.4 ± 257.8
11 July	211.5 ± 124.8	61.8 ± 19.7	273.4 ± 141.6
20 July	205.1 ± 30.4	59.6 ± 17.6	264.7 ± 37.1
1 August	413.3 ± 127.8	63.2 ± 27.1	476.5 ± 157.5
17 August	534.9 ± 128.9	77.8 ± 37.7	612.7 ± 171.2
12 September	416.2 ± 102.6	23.2 ± 7.8	439.4 ± 117.2
12 October	482.0 ± 107.3	28.9 ± 9.5	510.9 ± 124.2
7 November	1008.2 ± 425.3	51.8 ± 29.5	1060.0 ± 498.0

Table 2b (concl.)

Date	Total *Chironomus* spp. Biomass	Other Taxa Biomass	Total Macroinvertebrate Biomass
1991			
6 May	6808.0 ± 841.6	118.1 ± 49.3	6926.1 ± 976.3
22 May	1521.4 ± 457.2	10.3 ± 6.5	1531.7 ± 503.2
29 May	1683.9 ± 470.5	0.5 ± 0.5	1684.4 ± 519.1
13 June	2611.2 ± 771.7	24.7 ± 20.5	2635.9 ± 844.8
26 June	2567.2 ± 1307.5	20.5 ± 11.9	2587.8 ± 1438.2
10 July	4035.0 ± 2116.5	34.6 ± 5.6	4069.6 ± 2338.7
24 July	3602.7 ± 429.2	33.9 ± 15.0	3636.6 ± 473.4
7 August	2864.0 ± 1047.6	18.9 ± 15.5	2882.9 ± 1166.3
21 August	3249.5 ± 1528.8	0.2 ± 0.2	3249.7 ± 1686.2
7 September	4626.3 ± 2225.8	13.3 ± 7.7	4639.5 ± 2459.8
17 September	3546.7 ± 1871.4		3546.7 ± 2064.0
2 October	3746.9 ± 1853.9	9.1 ± 4.6	3755.9 ± 2040.3
29 October	2543.1 ± 1272.3	24.9 ± 1.0	2567.9 ± 1404.2

Table 6 (cont.)

1989

Date	Depth (m)	C. anthracinus	C. cucini	C. plumosus gp.	Pupae
14 May	15	48.5 ± 28.3	436.4 ± 324.0	194.0 ± 96.0	113.1 ± 106.1
	20		5.4 ± 5.4	26.9 ± 10.3	
	25				
27 May	15	43.1 ± 30.5	150.9 ± 53.5	156.2 ± 55.2	
	20		5.4 ± 5.4	32.3 ± 32.3	
	25				
16 June	15	86.2 ± 79.2	323.3 ± 180.1	177.8 ± 77.4	
	20		5.4 ± 5.4	32.3 ± 13.9	
	25				
30 June	15	75.4 ± 61.9	409.5 ± 245.4	226.3 ± 148.4	
	20		10.8 ± 10.8	5.4 ± 5.4	
	25		10.8 ± 10.8		
14 July	15	43.1 ± 23.3	231.7 ± 115.2	188.6 ± 85.0	
	20		10.8 ± 10.8	75.4 ± 10.8	
	25			10.8 ± 10.8	
27 July	15	10.8 ± 10.8	220.9 ± 130.3	97.0 ± 32.3	
	20		16.2 ± 5.4	37.7 ± 13.6	
	25				
8 August	15	32.3 ± 25.6	274.8 ± 204.1	102.4 ± 29.7	
	20		5.4 ± 5.4	16.2 ± 5.4	
	25				
28 August	15	5.4 ± 5.4	75.4 ± 28.5	48.5 ± 22.2	
	20		16.2 ± 16.2	5.4 ± 5.4	
	25		10.8 ± 10.8		
9 September	15	134.7 ± 107.9	129.3 ± 57.7	64.7 ± 31.7	
	20				
	25				
4 October	15	26.9 ± 20.4	194.0 ± 91.9	97.0 ± 32.3	
	20		16.2 ± 10.3	21.6 ± 15.2	
	25				
3 November	15	-----	-----	-----	-----
	20		10.8 ± 10.8	32.3 ± 20.6	
	25			21.6 ± 21.6	10.8 ± 10.8

Table 2c. Mean near- and far-end Chironomus spp., other taxa and total macroinvertebrate biomasses ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the south basin of Amisk Lake (South Amisk), 1988-1991. Blanks indicate no macroinvertebrates were collected.

Date	Total Chironomus spp. Biomass	Other Taxa Biomass	Total Macroinvertebrate Biomass
1990 (near end)			
10 May	76.8 ± 54.0	1.6 ± 1.6	78.4 ± 58.8
27 May	86.5 ± 59.7	36.7 ± 17.5	123.1 ± 70.5
14 June	78.4 ± 40.1	99.4 ± 28.7	177.8 ± 42.6
26 June	413.1 ± 359.2	150.0 ± 112.6	563.1 ± 507.9
11 July	322.2 ± 253.6	100.2 ± 27.3	422.4 ± 276.1
20 July	251.5 ± 37.3	77.3 ± 33.6	328.7 ± 20.9
1 August	669.7 ± 170.3	111.2 ± 41.4	780.9 ± 195.8
17 August	612.4 ± 181.5	113.0 ± 74.0	725.4 ± 273.9
12 September	564.3 ± 135.3	26.8 ± 12.9	591.2 ± 161.8
12 October	340.6 ± 77.3	7.1 ± 5.5	347.7 ± 89.6
7 November	1484.5 ± 831.3	88.2 ± 56.2	1572.7 ± 971.8
1990 (far end)			
10 May	13.9 ± 3.0	21.5 ± 8.7	35.4 ± 11.3
27 May	68.3 ± 28.4	31.0 ± 12.6	99.3 ± 30.4
14 June	121.3 ± 96.6	36.9 ± 20.5	158.2 ± 103.1
26 June	36.9 ± 21.3	10.8 ± 10.0	47.8 ± 30.6
11 July	100.8 ± 12.7	23.4 ± 9.1	124.3 ± 11.8
20 July	158.7 ± 38.7	42.0 ± 10.6	200.7 ± 53.1
1 August	156.9 ± 58.1	15.2 ± 13.1	172.1 ± 66.6
17 August	457.4 ± 201.4	42.7 ± 17.6	500.0 ± 228.3
12 September	268.2 ± 127.4	19.6 ± 10.5	287.7 ± 139.0
12 October	623.5 ± 185.5	50.6 ± 8.7	674.1 ± 207.0
7 November	531.9 ± 41.5	15.4 ± 4.9	547.3 ± 49.7
1991 (near end)			
6 May	8224.4 ± 259.7	203.3 ± 5.5	8427.7 ± 280.9
22 May	1011.7 ± 477.7	7.1 ± 7.1	1018.8 ± 534.0
29 May	1888.6 ± 366.3	1.0 ± 1.0	1889.6 ± 405.0
13 June	1557.1 ± 267.6	43.0 ± 43.0	1600.1 ± 338.1
26 June	568.9 ± 295.1	18.7 ± 18.7	587.6 ± 306.8
10 July	491.8 ± 201.1	28.4 ± 6.5	520.2 ± 228.2
24 July	3416.1 ± 326.5	54.6 ± 17.8	3470.8 ± 342.3
7 August	1188.1 ± 712.2	5.2 ± 0.6	1193.3 ± 784.9
21 August	2033.1 ± 1102.3	0.3 ± 0.3	2033.4 ± 1216.1
7 September	1109.6 ± 8.8	9.4 ± 5.5	1119.0 ± 15.2
17 September	582.3 ± 162.1		582.3 ± 178.8
2 October	3615.7 ± 3031.3	10.7 ± 8.1	3626.4 ± 3335.3

Table 2c (concl.)

Date	Total *Chironomus* spp. Biomass	Other Taxa Biomass	Total Macroinvertebrate Biomass
1991 (far end)			
6 May	5391.5 ± 412.1	33.0 ± 6.5	5424.5 ± 461.0
22 May	2031.0 ± 711.6	13.6 ± 13.6	2044.6 ± 771.3
29 May	1479.2 ± 1053.6		1479.2 ± 1162.1
13 June	3665.3 ± 1131.3	6.5 ± 3.2	3671.7 ± 1244.5
26 June	4565.6 ± 1477.7	22.3 ± 22.3	4587.9 ± 1607.5
10 July	7578.2 ± 1314.5	40.7 ± 8.4	7618.9 ± 1458.2
24 July	3789.2 ± 963.9	13.3 ± 13.3	3802.5 ± 1076.4
7 August	4539.8 ± 678.8	32.6 ± 32.6	4572.5 ± 781.3
21 August	4466.0 ± 3138.3		4466.0 ± 3461.4
7 September	8142.9 ± 2233.9	17.1 ± 17.1	8160.1 ± 2480.9
17 September	6511.1 ± 1847.0		6511.1 ± 2037.1
2 October	3878.0 ± 3376.3	7.4 ± 7.4	3885.5 ± 3716.4
29 October	2543.1 ± 1272.3	24.9 ± 1.0	2567.9 ± 1404.2

Table 2d. Mean Chironomus spp., other taxa and total macroinvertebrate biomasses ($mg \cdot m^{-2}$ unpreserved dry weight) ± SE at 25 m in the south basin of Baptiste Lake (South Baptiste), 1988-1991. Blanks indicate no macroinvertebrates were collected.

Date	Total Chironomus spp. Biomass	Other Taxa Biomass	Total Macroinvertebrate Biomass
1988			
15 May		2409.8 ± 178.8	2409.8 ± 178.8
19 June	6.0 ± 2.2	834.1 ± 140.3	840.2 ± 141.0
9 July	8.7 ± 1.8	273.1 ± 41.2	281.8 ± 41.8
28 July	2.0 ± 1.3	190.1 ± 76.9	192.1 ± 75.8
10 August	7.2 ± 3.3	119.3 ± 13.2	126.4 ± 11.9
25 August	2.1 ± 1.2	976.1 ± 216.0	978.1 ± 215.3
11 September	4.1 ± 2.5	564.4 ± 67.6	568.5 ± 67.7
9 October	2.2 ± 1.5	1610.9 ± 112.9	1613.1 ± 111.4
5 November	3.8 ± 2.2	2001.2 ± 234.5	2005.0 ± 235.6
1989			
14 May		3071.7 ± 175.5	3071.7 ± 175.5
27 May		2175.8 ± 264.8	2175.8 ± 264.8
16 June		999.3 ± 53.8	999.3 ± 53.8
30 June	0.5 ± 0.5	652.6 ± 133.8	653.1 ± 133.5
14 July	0.9 ± 0.9	58.7 ± 34.0	59.5 ± 34.6
27 July		124.5 ± 31.0	124.5 ± 31.0
8 August		154.0 ± 29.3	154.0 ± 29.3
28 August		516.9 ± 91.8	516.9 ± 91.8
9 September		571.0 ± 30.9	571.0 ± 30.9
4 October		1630.6 ± 324.9	1630.6 ± 324.9
3 November	1.0 ± 0.7	6420.1 ± 265.0	6421.0 ± 265.4
1990			
11 May		12091.3 ± 1483.5	12091.3 ± 1483.5
29 May		4378.4 ± 454.5	4378.4 ± 454.5
15 June	2.3 ± 1.7	4318.8 ± 1272.4	4321.2 ± 1271.9
27 June		2215.4 ± 310.2	2215.4 ± 310.2
12 July		462.9 ± 131.3	462.9 ± 131.3
23 July		189.3 ± 23.0	189.3 ± 23.0
7 August		134.1 ± 16.7	134.1 ± 16.7
20 August		199.3 ± 35.7	199.3 ± 35.7
14 September	1.3 ± 1.3	899.1 ± 106.5	900.4 ± 106.5
13 October		1947.4 ± 153.0	1947.4 ± 153.0
8 November		3551.9 ± 462.7	3551.9 ± 462.7

Table 2d (concl.)

Date	Total *Chironomus* spp. Biomass	Other Taxa Biomass	Total Macroinvertebrate Biomass
1991			
9 May	0.8 ± 0.8	6492.8 ± 425.7	6493.6 ± 426.3
23 May	2.6 ± 1.6	3837.6 ± 429.5	3840.2 ± 428.2
31 May	0.4 ± 0.4	2997.0 ± 416.0	2997.4 ± 415.9
14 June		1016.6 ± 327.7	1016.6 ± 327.7
28 June	3.9 ± 3.9	909.1 ± 93.9	913.0 ± 92.3
8 July	0.0 ± 0.0	660.2 ± 35.1	660.2 ± 35.1
26 July	1.5 ± 1.5	134.5 ± 24.2	136.0 ± 24.2
8 August		126.7 ± 12.0	126.7 ± 12.0
23 August		76.4 ± 31.8	76.4 ± 31.8
8 September		59.5 ± 20.4	59.5 ± 20.4
18 September		62.9 ± 32.8	62.9 ± 32.8
30 October		72.1 ± 39.8	72.1 ± 39.8

Table 3a. Mean Chironomus spp. larval and pupal weights (mg unpreserved dry weight) ± SE at 25 m in the north basin of Atitsk Lake (North Amisk), 1988-1991. Blanks indicate no larvae or pupae were collected.

Date	C. anthracinus	C. cucini	C.decorus	C. plumosus gp.	Early instar larvae	Pupae
1988						
16 May		11.0 ± 8.5	1.6 -----			16.0 -----
10 June			9.9 ± 1.8			
24 June		9.6 -----	9.2 ± 1.0			
10 July	17.0 -----		11.1 ± 1.0		0.4 ± 0.3	
21 July		21.9 -----	9.9 ± 4.2		0.5 ± 0.4	
2 August			9.0 ± 1.9		1.8 ± 0.2	
23 August		13.9 -----	8.7 -----		0.9 ± 0.6	
8 September		12.5 -----	1.2 -----		1.9 ± 0.1	
7 October	5.0 -----	7.4 ± 7.0		32.3 -----	1.3 ± 0.3	
3 November	10.6 ± 1.0	17.8 ± 12.0	19.0 -----			
1989						
7 May	12.8 ± 1.7	6.4 -----	7.3 -----	34.5 -----		
25 May	14.7 ± 1.3		7.5 ± 0.6			
12 June	19.1 ± 0.4		8.6 ± 0.3			
23 June	19.2 ± 0.9	11.6 ± 1.4	10.4 ± 1.0	39.4 -----		
10 July	22.3 ± 2.8		10.9 ± 0.9	21.7 -----		
20 July	24.1 ± 1.6	19.5 -----	9.3 ± 0.7	11.5 ± 8.8		
3 August	22.0 ± 1.0	13.4 ± 1.6	10.5 ± 1.1	17.6 -----		
21 August	21.5 ± 1.1	22.5 ± 0.7				
7 September	14.9 ± 6.7	24.3 -----				
1 October	18.3 ± 2.1	19.1 -----		27.2 -----		
31 October	15.7 ± 4.2	7.9 ± 3.6	1.3 ± 0.3	39.3 ± 14.3		
1990						
9 May		10.2 ± 4.7	4.9 ± 1.5	26.9 ± 9.1	0.8 -----	12.6 ± 2.7
26 May	0.4 -----		5.3 ± 0.2	1.8 -----	2.1 -----	14.1 ± 2.0
11 June		16.8 ± 0.3	7.6 ± 1.5	31.3 -----	3.1 -----	
23 June		10.8 -----	8.1 ± 0.4	36.2 -----		
10 July	4.9 -----	7.4 ± 6.0	12.2 ± 1.0	18.7 ± 9.6	0.9 ± 0.2	
19 July		7.4 ± 4.1	13.9 ± 1.3	26.0 -----	2.1 ± 0.2	
3 August	5.8 ± 0.9	3.0 ± 1.1	11.6 ± 0.2	26.5 -----	3.5 ± 1.4	
16 August	7.5 ± 0.7	3.3 ± 1.9	15.0 -----			
11 September	5.4 ± 0.8	3.0 ± 0.9		25.5 ± 17.6		
11 October	8.8 ± 0.9	5.0 ± 1.9		14.7 -----	1.5 -----	
6 November	10.3 ± 1.6	7.1 ± 0.2	2.5 ± 0.0			
1991						
6 May	19.0 ± 1.2	17.1 ± 2.5	6.3 ± 0.3	18.6 ± 9.1		10.7 ± 0.5
21 May	17.1 ± 0.9	17.7 ± 0.9	7.5 ± 0.8	32.2 ± 7.0		14.2 ± 0.5
28 May	19.5 ± 1.3	15.4 ± 1.8	7.0 ± 0.4	18.6 ± 9.2		11.0 ± 2.3
11 June	18.9 ± 1.3	15.4 ± 1.5	9.9 ± 0.8	25.5 ± 7.1		
25 June	18.8 ± 1.0	14.9 ± 4.6	8.8 ± 1.2	20.7 ± 9.6		
9 July	24.7 ± 1.7	16.3 ± 5.9	10.5 ± 1.0	8.3 ± 6.9		
23 July	21.1 ± 1.5	15.5 ± 1.3	12.2 ± 0.7	11.7 ± 0.4		
6 August	23.3 ± 2.1	18.9 ± 0.9	11.4 ± 1.6	6.6 ± 5.2		
20 August	22.9 ± 0.8	18.9 ± 3.1		13.4 ± 10.7		
6 September	21.2 ± 1.4	21.6 ± 3.9	9.0 -----	21.3 ± 15.2		
17 September	23.1 ± 1.8	12.7 ± 2.8		19.9 ± 17.2		
2 October	19.7 ± 2.0	20.4 ± 1.7	1.4 -----	53.1 -----		
29 October	24.0 ± 0.8	18.2 ± 0.5	3.8 -----			

Table 3b. Mean whole-basin Chironomus spp. larval and pupal weights (mg unpreserved dry weight) ± SE at 25 m in the south basin of Amisk Lake (South Amisk), 1988-1991. Blanks indicate no larvae or pupae were collected.

Date	C. anthracinus	C. cucini	C.decorus	C. plumosus gp.	Early instar larvae	Pupae
1988						
24 May		18.1 ± 4.1				
14 June		15.5 ± 2.4	9.4 ± 2.2			
28 June	16.3 -----	11.9 ± 4.9	7.8 -----			
12 July	9.7 -----	17.7 -----	7.9 -----		0.2 -----	
26 July			8.6 -----			
4 August		5.1 -----	8.3 -----			
24 August		10.3 ± 6.8	11.1 ± 1.4			
9 September	11.5 -----	21.7 ± 0.8	11.5 -----	26.4 -----		
8 October	2.6 ± 0.9	15.3 -----	8.6 ± 2.4			
4 November	3.8 ± 0.9	6.3 ± 3.2	2.9 ± 1.7	15.6 -----	1.3 -----	
1989						
12 May			4.5 -----			
26 May	6.2 ± 1.0	18.3 -----	7.2 -----			
14 June	11.3 -----	4.8 -----	11.0 ± 4.6			
24 June		2.5 ± 0.1	10.6 -----			
12 July		12.1 -----				
21 July	19.3 ± 0.8	17.5 ± 1.3	10.3 -----			
4 August	14.5 -----		9.6 ± 0.0			
23 August	12.4 ± 1.6	11.9 ± 2.6	9.0 ± 0.1			
8 September		8.4 -----	10.7 -----			
2 October	8.7 ± 1.6	13.2 ± 1.2	9.9 -----			
31 October						
1990						
10 May	29.7 -----	4.7 ± 0.1	1.2 ± 0.1			6.2 ± 2.6
27 May		8.2 ± 3.9	8.9 -----			16.2 ± 2.2
14 June		19.5 ± 4.3	5.2 ± 0.8		1.2 -----	
26 June		13.4 ± 1.5	7.0 ± 0.4		0.3 -----	
11 July		4.7 ± 3.5	9.0 ± 0.8		1.0 ± 0.2	
20 July	7.3 -----	9.2 ± 4.0	13.9 ± 1.0		1.5 ± 0.2	
1 August	3.3 ± 0.5	3.1 ± 1.4	9.9 ± 1.9	0.9 -----	1.4 ± 0.5	
17 August	2.7 ± 0.4	3.1 ± 1.1	10.4 -----	8.7 ± 5.1		
12 September	2.6 ± 0.5	1.4 ± 0.5	11.2 ± 0.0	5.4 -----		
12 October	2.8 ± 0.3	1.3 ± 1.1	11.2 ± 0.0			
7 November	3.6 ± 0.2	2.0 ± 0.7	9.2 -----			
1991						
6 May	7.2 ± 0.7	5.8 ± 1.3	1.2 ± 0.5	10.5 -----		9.0 -----
22 May	9.4 ± 1.2	9.1 ± 2.0	1.3 ± 0.5			
29 May	8.3 ± 0.4	6.8 ± 0.9	1.2 ± 0.3			7.2 -----
13 June	13.8 ± 0.7	12.7 ± 1.3				
26 June	12.9 ± 0.7	14.0 ± 2.7	11.5 ± 0.4			
10 July	15.9 ± 1.5	17.1 ± 1.3	1.0 -----			8.8 -----
24 July	15.5 ± 1.4	15.0 ± 1.9	4.4 ± 1.6			
7 August	16.6 ± 0.2	14.3 ± 1.1	1.6 -----			
21 August	13.1 ± 0.9	14.8 ± 2.1	5.7 ± 1.7	2.9 -----		
7 September	15.6 ± 1.0	17.6 ± 1.1	6.5 ± 3.4			
17 September	11.7 ± 0.9	8.7 ± 3.3	10.9 -----			
2 October	12.9 ± 1.9	12.7 ± 1.4	10.7 -----			
29 October	7.4 ± 0.1	9.1 ± 0.6				

Table 3c. Mean near- and far-end Chironomus spp. larval and pupal weights (mg unpreserved dry weight) ± SE at 25 m south basin of Amisk Lake (South Amisk), 1990-1991. Blanks indicate no larvae or pupae were collected.

Date	C. anthracinus	C. cucini	C.decorus	C. plumosus gp.	Early instar larvae	Pupae
1990 (near end)						
10 May	29.7 -----	4.7 ± 0.1				8.7 -----
27 May		7.1 ± 1.8	8.9 -----			18.4 -----
14 June		14.3 ± 4.5	5.6 ± 1.3		1.2 -----	
26 June		14.2 ± 3.4	7.0 ± 0.4		0.3 -----	
11 July		8.1 ± 7.2	9.6 ± 0.2		1.0 ± 0.3	
20 July		15.2 ± 6.8	13.4 -----		1.9 ± 0.2	
1 August	3.8 ± 1.1	4.6 ± 2.8	12.6 ± 1.1	0.9 -----	2.2 ± 0.2	
17 August	2.8 ± 0.5	4.0 ± 1.9	10.4 -----	1.0 ± 0.2		
12 September	2.4 ± 0.7	1.9 ± 1.1	11.2 ± 0.0	5.4 -----		
12 October	2.6 ± 0.5	0.2 ± 0.0	11.2 ± 0.0			
7 November	3.6 ± 0.4	2.7 ± 1.4	9.2 -----			
1990 (far end)						
10 May			1.2 ± 0.1			3.6 -----
27 May		9.4 ± 7.0				14.0 -----
14 June		24.7 -----	4.9 ± 1.1			
26 June		12.6 ± 0.3				
11 July		1.4 ± 1.0	8.4 ± 1.1		1.1 ± 0.2	
20 July	7.3 -----	3.2 ± 3.0	14.3 ± 1.4		1.2 ± 0.1	
1 August	2.9 ± 0.6	1.5 ± 1.1	7.2 -----		0.7 -----	
17 August	2.6 ± 0.7	2.3 ± 1.2		16.4 -----		
12 September	2.7 ± 0.8	0.9 ± 0.2				
12 October	3.1 ± 0.4	2.4 ± 1.7				
7 November	3.6 ± 0.3	1.3 ± 0.5				
1991 (near end)						
6 May	6.5 ± 0.7	4.5 ± 1.6	1.2 ± 0.5	10.5 -----		9.5 -----
22 May	9.9 ± 1.7	7.0 ± 2.4	0.8 -----			7.2 -----
29 May	8.6 ± 0.6	6.7 ± 0.9	1.2 ± 0.3			
13 June	13.4 ± 1.2	12.1 ± 2.7				
26 June	12.5 ± 0.9		11.8 -----			
10 July	14.5 ± 2.4		1.0 -----			
24 July	13.5 ± 2.1	16.7 ± 3.9	4.4 ± 1.6			
7 August	16.6 ± 0.4		1.6 -----			
21 August	14.1 ± 0.9	12.8 -----	7.8 ± 2.6			
7 September	15.8 ± 0.6		9.7 ± 1.9			
17 September	13.0 ± 0.9	3.3 ± 1.2	10.9 -----			
2 October	11.7 ± 0.7	11.4 -----	10.7 -----			
1991 (far end)						
6 May	8.6 ± 0.9	8.4 ± 0.0				8.4 -----
22 May	8.4 ± 1.0	13.2 ± 0.7	1.8 -----			
29 May	7.8 ± 0.7	7.0 ± 2.8				7.2 -----
13 June	14.2 ± 1.0	13.3 ± 1.7				
26 June	13.3 ± 1.2	14.0 ± 2.7	11.1 -----			
10 July	17.2 ± 2.0	17.1 ± 1.3				8.8 -----
24 July	17.5 ± 0.3	13.4 ± 1.0				
7 August	16.6 ± 0.2	14.3 ± 1.1				
21 August	12.1 ± 1.2	15.8 ± 3.9	3.6 ± 1.5	2.9 -----		
7 September	15.4 ± 2.4	17.6 ± 1.1	0.0 -----			
17 September	10.3 ± 0.8	14.2 ± 1.8				
2 October	14.1 ± 4.2	13.4 ± 2.2				
29 October	7.4 ± 0.1	9.1 ± 0.6				

Table 3d. Mean Chironomus spp. larval and pupal weights (mg unpreserved dry weight) ± SE at 25 m in the south basin of Baptiste Lake (South Baptiste), 1988-1991. Blanks indicate no larvae or pupae were collected.

Date	C. cucini	C. plumosus group
1988		
15 May		
19 June	3.0 ± 1.4	4.5 ± 0.2
9 July		4.7 ± 1.0
28 July		4.1 ± 1.1
10 August		4.7 ± 0.4
25 August		4.2 ± 0.0
11 September		5.7 ± 0.6
9 October		4.4 ± 1.8
5 November	1.6 ----	4.7 ± 0.6
1989		
14 May		
27 May		
16 June		
30 June	2.0 ----	
14 July		3.5 ----
27 July		
8 August		
28 August	0.1 ----	
9 September		
4 October		
3 November		2.0 ± 0.9
1990		
11 May	2.7 ----	3.7 ± 0.6
29 May	1.3 ----	5.4 ± 2.8
15 June	2.5 ± 0.8	5.7 ± 0.5
27 June		4.2 ± 0.6
12 July	1.4 ± 1.1	4.6 ± 1.1
23 July		
7 August		3.4 ± 0.8
20 August	2.0 ----	2.3 ± 0.9
14 September	2.2 ----	5.5 ± 0.4
13 October		2.7 ± 0.3
8 November	2.0 ----	3.1 ----
1991		
9 May		5.9 ± 2.8
23 May		5.1 ± 1.2
31 May		1.5 ----
14 June		
28 June		7.8 ----
8 July		
26 July		6.1 ----
8 August		
23 August		
8 September		
18 September		
30 October		

Appendix E: Profundal macroinvertebrate biomass, water chemistry, and morphometric data from Alberta lakes, used in uni- and multivariate regressional analyses (Chapter 4).

Table 1. Open-water (May-November) dissolved oxygen (DO), water temperature, and profundal macroinvertebrate biomass data for 32 Alberta lakes: mean DO (MEDO) concentrations, minimum DO (MNDO) concentrations, anoxic period (AP), mean temperature (METE), maximum temperature (MXTE), year(s) of DO and temperature data collection, profundal macroinvertebrate biomass (PMB), PMB sampling depth (SD), and year of PMB data collection. DO and temperature data are from Alberta Environmental Protection, Water Quality Branch, except for Matchayaw Lake (Lane 1971), and Amisk, Baptiste, and Narrow lakes (EEP, unpubl. data). DO and temperature data were from the same depths sampled for PMB, or from as close to that depth as possible. Biomass was measured as, or converted to, wet weight. Blanks in AP column indicate that data were unavailable.

Lake	MEDO ($mg \cdot L^{-1}$)	MNDO ($mg \cdot L^{-1}$)	AP (wk)	METE (°C)	MXTE (°C)	Year	PMB ($g \cdot m^{-2}$)	SD (m)	Year	PMB Source
Amisk	2.2	0.2	6	7.8	9.9	1988	1.0	25.0	1988	this study
(north basin)	3.4	0.9	1	7.5	9.7	1989	7.0	25.0	1989	
	4.9	0.3	4	9.2	13.2	1990	8.4	25.0	1990	
	3.8	0.8	4	7.1	10.3	1991	35.8	25.0	1991	
Amisk	0.4	0.0	20	4.9	6.1	1988	1.1	25.0	1988	this study
(south basin)	1.4	0.0	14	5.4	6.2	1989	1.2	25.0	1989	
	3.4	0.0	8	5.8	6.2	1990	2.8	25.0	1990	
	2.1	0.2	12	4.2	5.4	1991	24.7	25.0	1991	
Baptiste	1.2	0.0	18	5.1	5.8	1988	6.7	25.0	1988	this study
(south basin)	1.4	0.0	16	6.5	7.0	1989	9.9	25.0	1989	
	2.2	0.0	16	5.6	6.1	1990	18.4	25.0	1990	
	1.0	0.0	19	4.3	4.8	1991	9.1	25.0	1991	
Battle	7.5	3.0	0	12.8	18.2	1983	136.9	7.9	1948	Miller and Macdonald 1950
Beauvais	0.6	0.1		13.6	16.9	1989-1990	13.9	10.5	1979	MacNeill 1979
Beaver	8.7	7.4	0	14.5	19.4	1986	3.3	5.8	1965	Pinsent 1967
	7.8	6.2	0	13.8	18.2		34.6	8.0		
	7.7	6.1	0	13.8	18.2		2.6	10.2		
Buck	7.4	2.0	0	13.3	19.7	1983	201.0	6.4	1949	Miller and Macdonald 1950
	5.6	1.3	0	12.4	17.7		100.5	11.0		
	7.6	1.8	0	13.1	18.1		37.4	7.6	1970	Bidgood 1972
	7.6	1.8	0	13.1	18.1		38.7	7.6	1971	
Calling	8.5	7.6	0	12.2	17.8	1988	9.1	11.3	1949	Miller and Macdonald 1950
	5.7	1.0	1	11.7	17.1		59.3	16.5		
Chestermere	9.4	3.6	0	14.0	19.5	1983	68.9	5.9	1969	Thompson 1971a
Crimson	9.1	7.3	0	12.9	19.5	1978	18.3	6.4	1950	Miller & Paetz 1953
Eagle	7.0	2.6	0	14.5	18.2	1988	15.1	4.6	1969	Thompson 1971b
Elkwater	7.5	5.2		17.6	19.8	1984-1993	12.9	6.4	1947	Miller and Macdonald 1950
Gull	6.2	1.9	0	14.2	20.0	1979	37.7	8.0	1969	Kraft 1977
Isle	6.5	0.1	2	12.9	18.5	1984	9.8	5.5	1969	Lane 1971
	6.5	0.1	2	12.9	18.5		14.4	8.0		

Table 1 (cont.)

Lake	MEDO ($mg \cdot L^{-1}$)	MNDO ($mg \cdot L^{-1}$)	AP (wk)	METE (°C)	MXTE (°C)	Year	PMB ($g \cdot m^{-2}$)	SD (m)	Year	PMB Source
Kananaskis	9.7	8.5	0	10.2	11.2	1984	2.2	9.0	1937	Rawson 1937
(Upper)	9.6	8.5	0	9.4	9.7		0.2	12.0		
	9.4	8.5	0	8.9	9.3		0.5	15.0		
	9.3	8.5	0	8.7	9.3		7.2	17.0		
	8.9	8.2	0	7.6	7.9		3.9	28.0		
	8.6	7.7	0	6.1	7.8		1.6	56.0		
Kananaskis	9.2	8.2	0	9.9	13.3	1984	6.6	10.5	1937	Rawson 1937
(Lower)	8.7	7.7	0	8.0	9.9		30.4	20.0		
	9.2	8.2	0	9.9	13.3		41.1	11.0	1954	Miller 1955
	9.2	8.2	0	9.4	11.8		36.5	12.5		
	9.2	8.1	0	9.1	11.0		13.7	14.3		
	8.9	7.9	0	8.1	10.0		9.1	18.9		
	8.5	7.1	0	7.7	9.2		18.3	21.0		
	8.0	6.1	0	7.3	8.3		2.3	25.0		
	7.9	6.0	0	7.2	8.2		4.6	26.8		
	7.9	6.0	0	7.2	8.1		2.3	29.3		
Lac la Biche	8.6	7.2	0	14.5	19.0	1988	101.3	5.8	1965	Pinsent 1967
	8.3	5.5	0	14.4	18.8		39.0	8.5		
	8.0	4.7	0	14.0	18.3		22.4	12.0		
	6.7	3.6	0	13.3	18.0		68.8	17.0		
	4.8	0.2	5	12.9	17.4		79.2	22.0		
Lac Ste. Anne	6.5	0.0	2	12.7	18.0	1984	14.0	5.5	1969	Lane 1971
(west basin)	5.9	0.0	2	12.7	17.9		7.0	8.5		
Lac Ste. Anne	8.3	4.4	0	12.2	18.9	1984	9.4	5.5	1969	Lane 1971
(east basin)	7.4	1.6	0	11.9	18.0		23.3	8.5		
Lesser Slave	7.6	0.1	1	10.6	15.1	1992	33.9	18.0	1975	Weisgerber 1977
Marie	5.4	0.0	6	8.9	12.6	1980	18.3	18.3	1950	Miller & Paetz 1953
	9.2	4.6	0	13.0	18.0		1.3	8.0	1977	Cross 1979
	6.4	0.4	2	10.0	14.5		1.1	13.0		
Matchayaw	4.2	3.0	0	16.7	17.7	1969	29.2	5.0	1969	Lane 1971
	1.0	0.3	7	14.9	17.5		4.5	8.5		
McGregor	8.0	4.6	0	13.1	20.8	1984	4.6	9.7	1957	English 1985a
	8.0	4.6	0	13.1	20.8		5.2	9.0		

Table 1 (concl.)

Lake	MEDO ($mg \cdot L^{-1}$)	MNDO ($mg \cdot L^{-1}$)	AP (wk)	METE (°C)	MXTE (°C)	Year	PMB ($g \cdot m^{-2}$)	SD (m)	Year	PMB Source
Musreau	8.4	7.4		12.1	15.1	1983, 1986	0.5	6.8	1974	Schroeder 1974
	7.8	6.2		11.8	14.5		3.1	8.4		
	7.3	5.3		11.4	13.7		8.4	9.9		
	7.1	5.0		11.1	13.6		8.0	11.5		
	7.1	5.0		11.1	13.6		7.9	12.2		
Narrow	3.6	0.4	7	5.5	6.0	1983	6.5	22.5	1983	J.M. Hanson unpubl. data
	2.2	0.3	12	5.3	5.8		3.0	32.5		
Newell	8.5	6.2	0	15.0	20.4	1983	4.1	19.8	1981	English 1985b
Pigeon	7.5	4.4	0	17.3	20.0	1983-1992	46.1	9.0	1970	Bidgood 1972
	7.5	4.4	0	17.3	20.0		39.1	9.0	1971	
Reesor	7.9	4.7	0	16.4	19.8	1983-1993	7.0	6.0	1979	English 1979
Skeleton	2.1	0.0	12	8.4	10.3	1986	10.8	10.0	1988	this study
(north basin)	1.1	0.0	14	6.7	7.8		2.9	15.0		
Skeleton	8.5	6.7	0	14.0	17.8	1986	0.4	6.1	1947	Miller and Macdonald 1950
(south basin)	5.0	0.0	5	13.4	17.8		49.0	10.0	1988	this study
Spray Lakes	8.9	8.1	0	10.2	13.4	1984	0.7	9.0	1975	Wiebe 1975
	9.0	8.1	0	8.6	10.2		4.6	14.0		
	8.4	7.0	0	6.7	7.8		2.5	35.0		
Sturgeon	8.5	7.1	0	12.8	18.7	1984	52.5	5.0	1970	Bishop 1971
	8.1	5.9	0	12.7	18.5		65.9	7.0		
	7.1	4.7	0	12.6	18.3		67.6	9.0		
Sylvan	8.9	7.0	0	13.5	18.8	1974	31.9	9.2	1942	Miller 1942
	8.9	7.1	0	13.3	18.8		9.1	10.8		
	8.7	7.1	0	13.2	18.7		22.8	12.5		
Winagami	7.5	5.0		17.3	20.5	1983-1992	11.8	3.8	1973	Bishop 1976
Wolf	9.1	5.8	0	14.8	19.6	1981	3.5	6.0	1968	Robertson 1970
	5.7	0.0	4	10.9	15.2		2.2	11.0		
	3.5	0.0	4	6.8	9.5		1.6	16.0		
	3.3	0.0	4	5.5	6.2		1.1	21.0		

Table 2. Limnological parameters for 32 Alberta lakes with profundal macroinvertebrate biomass data: location, ecoregion, trophic status, epilimnetic summer chlorophyll a (CHLA) concentration, epilimnetic summer total phosphorus (TP) concentration, Secchi transparency (ST), specific conductivity (COND), mean depth (ZME), maximum depth (ZMX), mean depth-maximum depth ratio (MEMX), surface area (AREA), bottom slope (SL), colour (COL), dissolved organic carbon (DOC) concentration, pH, and year(s) of data collection. Colour data for Amisk, Baptiste, Calling, Isle, and Narrow lakes are from Mitchell and Prepas (1990); colour for other lakes was estimated with Equation (3) (this study). Data for other parameters are from Mitchell and Prepas (1990), except Matchayaw Lake (Lane 1971), and CHLA, TP, and ST data for Amisk and Baptiste lakes (EEP, unpubl. data). Blanks for Amisk and Baptiste lakes indicate repetitive data. Blanks elsewhere indicate that data were unavailable. '*' indicate colour data predicted with Equation (3) (Chapter 4).

Lake	Latitude/Longitude	Ecoregion	Trophic Status	CHLA ($\mu g \cdot L^{-1}$)	TP ($\mu g \cdot L^{-1}$)	ST (m)	COND ($\mu S \cdot cm^{-1}$)	ZME (m)	ZMX (m)	MEMX	AREA (km^2)	SL (%)	COL (mg Pt·L^{-1})	DOC ($mg \cdot L^{-1}$)	pH	Year
Amisk (north)	54°35'N 112°37'W	Boreal Mixedwood	Eutrophic	9	92	2.5	299	10.8	34.0	0.32	2.33	11.6	10	14	8.8	1982, 1988
				11	74	3.8										1989
				12	68	1.8										1990
				8	46	2.1										1991
Amisk (south)	54°35'N 112°37'W	Boreal Mixedwood	Eutrophic	9	104	2.5	295	19.4	60.0	0.32	2.82	14.0	10	13	8.4	1982, 1988
				11	88	3.5										1989
				11	71	1.7										1990
				8	63	2.2										1991
Baptiste (south)	54°45'N 113°33'W	Boreal Mixedwood	Eutrophic	25	141	1.9	343	11.9	27.5	0.43	4.74	4.4	25	17	8.2	1986, 1988
				26												1989
				30												1990
				23												1991
Battle	52°58'N 114°11'W	Boreal Mixedwood	Mesotrophic	13	29	3.7	352	6.9	13.1	0.53	4.56	5.1	11 *	9	8.3	1983, 1984
Beauvais	49°25'N 114°06'W	Montane	Mesotrophic	14	33	1.6	279	4.3	10.7	0.40	0.89	3.1	8	9	8.5	1984, 1985
Beaver	54°43'N 111°37'W	Boreal Mixedwood	Mesotrophic	11	33	2.9	409	7.1	15.2	0.47	33.10	1.6	15 *	15	7.3	1986
Buck	53°00'N 114°45'W	Boreal Foothills	Eutrophic	15	38	3.4	228	6.2	12.2	0.51	25.40	0.4	11 *	9	7.9	1984
Calling	55°15'N 113°19'W	Boreal Mixedwood	Eutrophic	19	50	2.7	168		18.3		138.00	0.3	14	10	8.0	1988
Chestermere	51°02'N 113°49'W	Fescue Grass	Mesotrophic	6	36	2.9	303	3.5	7.0	0.50	2.65	1.7	6	2	7.8	1983
Crimson	52°27'N 115°02'W	Boreal Foothills	Mesotrophic	5	17	3.8	257	2.2	9.1	0.24	2.32	1.2	5	12	8.9	1986
Eagle	51°00'N 113°19'W	Fescue Grass	Hypereutrophic	46	333	0.4	1828	2.6	4.9	0.53	11.80	0.3	42	21	8.9	1988
Elkwater	49°39'N 110°18'W	Boreal Foothills	Eutrophic	5	38	2.7	450	3.5	8.4	0.42	2.31	2.2	19	11	8.2	1983
Gull	52°34'N 114°00'W	Aspen Parkland	Eutrophic	7	36	2.9	1144	5.4	8.0	0.68	80.60	0.2	8	22	9.6	1983-1985
Isle	53°38'N 114°44'W	Boreal Mixedwood	Hypereutrophic	39	93	2.1	283	4.1	7.5	0.55	23.00	1.3	29	13	8.7	1983, 1984
Kananaskis (Upper)	50°40'N 115°10'W	Subalpine	Oligotrophic	3	5	2.2	168	32.0	108.0	0.30	7.80	14.9			7.8	1984
Kananaskis (Lower)	50°40'N 115°10'W	Subalpine	Oligotrophic	2	6	4.3	255	13.1	42.1	0.31	5.25	10.8			8.2	1984
Lac la Biche	54°52'N 112°05'W	Boreal Mixedwood	Hypereutrophic	23	117	2.5	288	8.4	21.3	0.39	234.00	1.0	11 *	10	8.4	1988
Lac Ste. Anne (west)	53°42'N 114°25'W	Boreal Mixedwood	Eutrophic	33	44	1.6	288	4.8	7.0	0.53	10.90	0.8	12 *	11	8.6	1984
Lac Ste. Anne (east)	53°42'N 114°25'W	Boreal Mixedwood	Eutrophic	18	48	2.2	305	4.8	9.0	0.53	43.60	0.3	11 *	9	8.5	1984
Lesser Slave	55°27'N 115°26'W	Boreal Mixedwood	Eutrophic	0	45	2.3	221	11.4	20.5	0.56	1160.00	0.4	17	11	7.3	1989
Marie	54°38'N 110°18'W	Boreal Mixedwood	Mesotrophic	5	15	3.0	256	14.0	26.0	0.54	34.60	1.6	11 *	10	8.0	1980

Table 2 (concl.)

Lake	Latitude/Longitude	Ecoregion	Trophic Status	CHLA ($\mu g \cdot L^{-1}$)	TP ($\mu g \cdot L^{-1}$)	ST (m)	COND ($\mu S \cdot cm^{-1}$)	ZME (m)	ZMX (m)	MEMX	AREA (km^2)	SL (%)	COL (mg Pt·L^{-1})	DOC ($mg \cdot L^{-1}$)	pH	Year
Matchayaw	53°N 114°W	Boreal Mixedwood	Eutrophic	19	50	0.8	629	5.5	10.7	0.51		3.7			8.2	1969, 1994
McGregor	50°24'N 112°50'W	Mixed Grass	Mesotrophic	9	30	1.6	330	6.5	9.7	0.67	51.40	1.2	8	2	7.9	1984
Musreau	54°33'N 118°37'W	Boreal Foothills	Mesotrophic	5	23	2.1	171		13.0		5.49	1.2	18 *	19	8.1	1986
Narrow	54°35'N 113°37'W	Boreal Mixedwood	Mesotrophic	3	11	6.3	286	14.4	38.0	0.38	1.14	19.2	8	11	8.2	1983
Newell	50°25'N 111°57'W	Short Grass	Mesotrophic	12	32	2.4	344	4.8	19.8	0.24	66.40	0.9	6	3	8.0	1983
Pigeon	53°01'N 114°02'W	Boreal Mixedwood	Mesotrophic	12	29	2.9	283	6.2	9.1	0.68	96.70	0.5	1	7	8.4	1983, 1984
Reesor	49°40'N 110°07'W	Boreal Foothills	Eutrophic	14	36	2.9	234	3.7	5.5	0.67	0.51	2.2	7	5	8.1	1983-1987
Skeleton (north)	54°37'N 112°44'W	Boreal Mixedwood	Eutrophic	11	36	2.5	318	6.5	17.0	0.38	1.32	3.1	15 *	15	8.6	1985
Skeleton (south)	54°37'N 112°44'W	Boreal Mixedwood	Eutrophic	24	47	1.6	333	6.5	11.0	0.38	6.57	0.8	14 *	14	8.7	1985
Spray Lakes	50°54'N 115°20'W	Subalpine	Oligotrophic	2	4	5.9	271	13.5	65.4	0.21	19.90	11.5			7.8	1984
Sturgeon	55°06'N 117°32'W	Boreal Mixedwood	Eutrophic	45	92	1.6	158	5.4	9.5	0.57	49.10	0.3	21	17	8.2	1984
Sylvan	52°18'N 114°06'W	Boreal Mixedwood	Mesotrophic	4	20	5.0	597	9.6	18.3	0.52	42.80	0.8	2	8	8.9	1986
Winagami	55°38'N 116°45'W	Boreal Mixedwood	Hypereutrophic	37	119	1.3	453	1.7	4.7	0.36	46.70	0.2	24	25	8.6	1984
Wolf	54°41'N 110°57'W	Boreal Mixedwood	Mesotrophic	8	25	2.8	300	9.2	38.3	0.24	31.50	3.5	14 *	13	8.0	1981

Table 3. Colour and dissolved organic carbon (DOC) data for 77 Alberta lakes between 56° and 49° N latitude. Unless otherwise referenced, data are from Alberta Environmental Protection (unpublished data).

Lake	Colour ($mg\ Pt \cdot L^{-1}$)	DOC ($mg \cdot L^{-1}$)
Agnes	72	20
Alix	28	27
Amisk North	10 c	14 d
Amisk South	10 c	13 d
Baptiste North 1986	22 c	17 c
Baptiste North 1991	16 d	18 d
Baptiste North 1992	12 d	14 d
Baptiste South 1986	25 c	17 c
Baptiste South 1991	15 d	23 d
Baptiste South 1992	12 d	14 d
Battle River	46	17
Beauvais	8	9
Buffalo Main	8	41
Burntstick	7	5
Bushy Head	24	33
Calling	14 c	10 c
Chestermere	6	2
Coal	20 d	22 d
Cold	5 b	9 c
Cow	6	12
Crimson	5	12
Christina	17	11
Crooked 1991	9 d	18 d
Crooked 1992	11 d	14 d
Dilberry	5	10
Driedmeat	38 d	23 d
Eagle	42	21
Elkwater	19	11
Emerson	5	2
Ethel	10 b	11 c
Ethel 198	28	16
Figure Eight 1986	28 c	18 c
Figure Eight 1987	17 d	15 d
Figure Eight 1991	15 d	20 d
Figure Eight 1992	14 d	15 d
Freeman	50	10
Garner	7	23
Gregoire	23	14
Gull	8	22

Table 3. (cont)

Lake	Colour (mg Pt·L^{-1})	DOC (mg·L^{-1})
Halfmoon 1988	15 d	17 d
Halfmoon 1992	17 d	18 d
Hastings 1983/87	19 a	36 c
Hastings 1991	23 d	36 d
Isle	29 d	23 d
Jackpine	122	34
Jenkins 1991	5 d	15 d
Jenkins 1992	8 d	12 d
Jensen	3	2
Lac la Nonne	21 d	24 d
Lesser Slave East	14	10
Lesser Slave West	19	11
Lingrell	27	19
Little Beaver	35 d	32 d
Little Bow	6	2
Lofty 1991	16 d	26 d
Lofty 1992	18 d	25 d
Long (near Pigeon)	15	11
Marigold	3	5
Marten	84	16
McGregor	8	2
McLeod	12	10
Milk River Ridge	5	2 c
Moonshine	58	34
Moore	5 a	15 c
Moose	12	18
Nakamun 1983	25 c	16 c
Nakamun 1991	24 d	24 d
Namur	9	8
Narrow	8 c	11 d
Newell 1983	6	3
Newell 1993	3	3
North Buck	9	33 c
North Halfmoon 1991	18 d	20 d
North Halfmoon 1992	17 d	20 d
Oldman	5	3
Paddle River	85	20
Pigeon	1	7
Reesor	7	5
Saskatoon	42	59
South Heart	17	25

Table 3. (concl)

Lake	Colour ($mg\ Pt \cdot L^{-1}$)	DOC ($mg \cdot L^{-1}$)
Spring	10 c	14 c
Squaw Coulee	9	2
St. Mary	5	1
Steele 1987	29	17
Steele 1994	17 d	21 d
Sturgeon Main	21	16
Sturgeon West	46	19
Swartz	24	10
Sylvan	2	8
Tea North	13	18
Tea South	22	30
Thunder	24	31
Trap	43	22
Travers 1983	5	2
Travers 1993	2	4
Tucker	10 b	12 c
Two	16	8
Wabamun East	9	12
Wabamun West	10	12
Winagami	24	25
Mean	19	16
SE	2	1
range	1 - 122	1 - 59
n	100	100

a Prepas and Trew (1983)
b Chambers and Prepas (1988)
c Mitchell and Prepas (1990)
d EEP (unpubl. data)

Appendix F: Identification key for Chironomus species collected from Amisk and Baptiste lakes, 1988-1991.

A simple key for the identification of Chironomus spp. larvae from Amisk and Baptiste lakes, based on Lindeberg and Wiederholm (1979). Many species of Chironomus from other lakes will also key out to the larval types listed below.

1. Eighth abdominal segment with 1 or 2 pairs of ventral tubuli; seventh abdominal segment with or without one pair of lateral tubuli 2

Seventh and eighth abdominal segments without tubuli ..... salinarius-type (Chironomus cucini in part)

2. Eighth abdominal segment with one pair of stout, club-like ventral tubuli; seventh abdominal segment without tubuli ..... Chironomus cucini in part

Eighth abdominal segment with two pairs of slender ventral tubuli; seventh abdominal segment with or without lateral tubuli 3

3. Seventh abdominal segment with 1 pair of well-developed lateral tubuli; fourth-instar larvae more than 20 mm long ..... plumosus-type (Chironomus plumosus group)

Seventh abdominal segment with very small or no lateral tubuli; fourth-instar larvae less than 20 mm long 4

4. Length of ventral tubuli equal to or less than length of eighth abdominal segment, distal ends rounded ..... anthracinus-type (Chironomus anthracinus)

Length of ventral tubuli greater than length of eighth abdominal segment, distal ends pointed ..... fluviatilis-type (Chironomus decorus)